



Glossary

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acquired trait: A [phenotypic](#) characteristic, acquired during growth and development, that is not genetically based and therefore cannot be passed on to the next generation (for example, the large muscles of a weightlifter).

adaptation: Any heritable characteristic of an organism that improves its ability to survive and reproduce in its environment. Also used to describe the process of genetic change within a population, as influenced by [natural selection](#).

adaptive landscape: A graph of the average [fitness](#) of a population in relation to the frequencies of [genotypes](#) in it. Peaks on the landscape correspond to genotypic frequencies at which the average fitness is high, valleys to genotypic frequencies at which the average fitness is low. Also called a fitness surface.

adaptive logic: A behavior has adaptive logic if it tends to increase the number of offspring that an individual contributes to the next and following generations. If such a behavior is even partly genetically determined, it will tend to become widespread in the population. Then, even if circumstances change such that it no longer provides any survival or reproductive advantage, the behavior will still tend to be exhibited -- unless it becomes positively disadvantageous in the new environment.

adaptive radiation: The diversification, over evolutionary time, of a [species](#) or group of species into several different species or subspecies that are typically adapted to different ecological [niches](#) (for example, Darwin's finches). The term can also be applied to larger groups of organisms, as in "the adaptive radiation of [mammals](#)."

adaptive strategies: A mode of coping with competition or environmental conditions on an evolutionary time scale. [Species](#) adapt when succeeding

generations emphasize beneficial characteristics.

agnostic: A person who believes that the existence of a god or creator and the nature of the universe is unknowable.

algae: An umbrella term for various simple organisms that contain chlorophyll (and can therefore carry out [photosynthesis](#)) and live in [aquatic](#) habitats and in moist situations on land. The term has no direct [taxonomic](#) significance. Algae range from macroscopic seaweeds such as giant kelp, which frequently exceeds 30 m in length, to microscopic filamentous and single-celled forms such as *Spirogyra* and *Chlorella*.

allele: One of the alternative forms of a gene. For example, if a [gene](#) determines the seed color of peas, one allele of that gene may produce green seeds and another allele produce yellow seeds. In a [diploid](#) cell there are usually two alleles of any one gene (one from each parent). Within a population there may be many different alleles of a gene; each has a unique [nucleotide](#) sequence.

allometry: The relation between the size of an organism and the size of any of its parts. For example, an allometric relation exists between brain size and body size, such that (in this case) animals with bigger bodies tend to have bigger brains. Allometric relations can be studied during the growth of a single organism, between different organisms within a species, or between organisms in different species.

allopatric speciation: [Speciation](#) that occurs when two or more populations of a species are geographically isolated from one another sufficiently that they do not interbreed.

allopatry: Living in separate places. Compare with [sympatry](#).

amino acid: The unit molecular building block of [proteins](#), which are chains of amino acids in a certain sequence. There are 20 main amino acids in the proteins of living things, and the properties of a protein are determined by its particular amino acid sequence.

amino acid sequence: A series of amino acids, the building blocks of [proteins](#), usually coded for by [DNA](#). Exceptions are those coded for by the [RNA](#) of certain viruses, such as HIV.

ammonoid: [Extinct](#) relatives of cephalopods (squid, octopi, and chambered nautilus), these [mollusks](#) had coiled shells and are found in the [fossil](#) record of the [Cretaceous](#) period.

amniotes: The group of reptiles, birds, and [mammals](#). These all develop through an [embryo](#) that is enclosed within a membrane called an amnion. The amnion surrounds the embryo with a watery substance, and is probably an adaptation for breeding on land.

amphibians: The class of [vertebrates](#) that contains the frogs, toads, newts, and salamanders. The amphibians evolved in the Devonian period (about 370 million years ago) as the first vertebrates to occupy the land. They have moist

scaleless skin which is used to supplement the lungs in gas exchange. The eggs are soft and vulnerable to drying, therefore reproduction commonly occurs in water. Amphibian larvae are aquatic, and have gills for respiration; they undergo [metamorphosis](#) to the adult form. Most amphibians are found in damp environments and they occur on all continents except Antarctica.

analogous structures: Structures in different species that look alike or perform similar functions (e.g., the wings of butterflies and the wings of birds) that have evolved [convergently](#) but do not develop from similar groups of [embryological](#) tissues, and that have not evolved from similar structures known to be shared by common ancestors. Contrast with [homologous structures](#). Note: The recent discovery of deep genetic homologies has brought new interest, new information, and discussion to the classical concepts of analogous and homologous structures.

anatomy: (1) The structure of an organism or one of its parts. (2) The science that studies those structures.

ancestral homology: [Homology](#) that evolved before the [common ancestor](#) of a set of [species](#), and which is present in other species outside that set of species. Compare with [derived homology](#).

anthropoid: A member of the group of primates made up of monkeys, apes, and humans.

antibacterial: Having the ability to kill [bacteria](#).

antibiotics: Substances that destroy or inhibit the growth of microorganisms, particularly disease-causing [bacteria](#).

antibiotic resistance: A [heritable](#) trait in microorganisms that enables them to survive in the presence of an [antibiotic](#).

aperture: Of a camera, the adjustable opening through which light passes to reach the film. The diameter of the aperture determines the intensity of light admitted. The pupil of a human eye is a self-adjusting aperture.

aquatic: Living underwater.

arboreal: Living in trees.

archeology: The study of human history and prehistory through the excavation of sites and the analysis of physical remains, such as graves, tools, pottery, and other [artifacts](#).

archetype: The original form or body plan from which a group of organisms develops.

artifact: An object made by humans that has been preserved and can be studied to learn about a particular time period.

artificial selection: The process by which humans breed animals and cultivate crops to ensure that future generations have specific desirable [characteristics](#). In

artificial selection, breeders select the most desirable variants in a plant or animal population and selectively breed them with other desirable individuals. The forms of most domesticated and agricultural species have been produced by artificial selection; it is also an important experimental technique for studying evolution.

asexual reproduction: A type of reproduction involving only one parent that usually produces [genetically](#) identical offspring. Asexual reproduction occurs without fertilization or genetic [recombination](#), and may occur by budding, by division of a single cell, or by the breakup of a whole organism into two or more new individuals.

assortative mating: The tendency of like to mate with like. Mating can be assortative for a certain [genotype](#) (e.g., individuals with genotype AA tend to mate with other individuals of genotype AA) or [phenotype](#) (e.g., tall individuals mate with other tall individuals).

asteroid: A small rocky or metallic body orbiting the Sun. About 20,000 have been observed, ranging in size from several hundred kilometers across down to dust particles.

atheism: The doctrine or belief that there is no god.

atomistic: (as applied to theory of inheritance) Inheritance in which the entities controlling [heredity](#) are relatively distinct, permanent, and capable of independent action. [Mendelian inheritance](#) is an atomistic theory because in it, inheritance is controlled by distinct [genes](#).

australopithecine: A group of [bipedal hominid species](#) belonging to the [genus](#) *Australopithecus* that lived between 4.2 and 1.4 mya

***Australopithecus afarensis*:** An early australopithecine [species](#) that was [bipedal](#); known [fossils](#) date between 3.6 and 2.9 mya (for example, Lucy).

autosome: Any [chromosome](#) other than a sex chromosome.

avian: Of, relating to, or characteristic of birds (members of the [class](#) Aves).

bacteria: Tiny, single-celled, [prokaryotic](#) organisms that can survive in a wide variety of environments. Some cause serious infectious diseases in humans, other animals, and plants.

base: The [DNA](#) molecule is a chain of [nucleotide](#) units; each unit consists of a backbone made of a sugar and a phosphate group, with a nitrogenous base attached. The base in a unit is one of adenine (A), guanine (G), cytosine (C), or thymine (T). In RNA, uracil (U) is used instead of thymine. A and G belong to the chemical class called [purines](#); C, T, and U are [pyrimidines](#).

Batesian mimicry: A kind of [mimicry](#) in which one non-poisonous [species](#) (the Batesian mimic) mimics another poisonous species.

belemnite: An [extinct](#) marine invertebrate that was related to squid, octopi, and chambered nautilus. We know from the [fossil](#) record that belemnites

were common in the Jurassic period and had bullet-shaped internal skeletons.

big bang theory: The theory that states that the universe began in a state of compression to infinite density, and that in one instant all matter and energy began expanding and have continued expanding ever since.

biodiversity (or biological diversity): A measure of the variety of life, biodiversity is often described on three levels. Ecosystem diversity describes the variety of habitats present; [species](#) diversity is a measure of the number of species and the number of individuals of each species present; genetic diversity refers to the total amount of genetic variability present.

bioengineered food: Food that has been produced through [genetic](#) modification using techniques of genetic engineering.

biogenetic law: Name given by [Haeckel](#) to [recapitulation](#).

biogeography: The study of patterns of geographical distribution of plants and animals across Earth, and the changes in those distributions over time.

biological species concept: The concept of [species](#), according to which a species is a set of organisms that can interbreed among each other. Compare with [cladistic species concept](#), [ecological species concept](#), [phenetic species concept](#), and [recognition species concept](#).

biometrics: The quantitative study of characters of organisms.

biosphere: The part of Earth and its atmosphere capable of sustaining life.

bipedalism: Of [hominids](#), walking upright on two hind legs; more generally, using two legs for locomotion.

bivalve: A [mollusk](#) that has a two-part hinged shell. Bivalves include clams, oysters, scallops, mussels, and other shellfish.

Blackmore, Susan: A psychologist interested in [memes](#) and the theory of memetics, evolutionary theory, consciousness, the effects of meditation, and why people believe in the paranormal. A recent book, *The Meme Machine*, offers an introduction to the subject of memes.

blending inheritance: The historically influential but factually erroneous theory that organisms contain a blend of their parents' [hereditary](#) factors and pass that blend on to their offspring. Compare with [Mendelian inheritance](#).

botanist: A scientist who studies plants.

brachiopod: Commonly known as "lamp shells," these marine invertebrates resemble [bivalve mollusks](#) because of their hinged shells. Brachiopods were at their greatest abundance during the Paleozoic and Mesozoic eras.

Brodie, Edmund D., III: A biologist who studies the causes and evolutionary implications of interactions among traits in predators and their prey. Much of his work concentrates on the [coevolutionary](#) arms race between newts that

possess tetrodotoxin, one of the most potent known toxins, and the resistant garter snakes who prey on them.

Brodie, Edmund D., Jr.: A biologist recognized internationally for his work on the evolution of mechanisms in amphibians that allow them to avoid predators. These mechanisms include toxins carried in skin secretions, coloration, and behavior.

Bruner, Jerome: A psychologist and professor at Harvard and Oxford Universities, and a prolific author whose book, *The Process of Education*, encouraged curriculum innovation based on theories of cognitive development.

bryozoan: A tiny marine invertebrate that forms a crust-like colony; colonies of bryozoans may look like scaly sheets on seaweed.

Burney, David: A biologist whose research has focused on endangered species, paleoenvironmental studies, and causes of extinction in North America, Africa, Madagascar, Hawaii, and the West Indies.

carbon isotope ratio: A measure of the proportion of the carbon-14 [isotope](#) to the carbon-12 isotope. Living material contains carbon-14 and carbon-12 in the same proportions as exists in the atmosphere. When an organism dies, however, it no longer takes up carbon from the atmosphere, and the carbon-14 it contains decays to nitrogen-14 at a constant rate. By measuring the carbon-14-to-carbon-12 ratio in a fossil or organic artifact, its age can be determined, a method called radiocarbon dating. Because most carbon-14 will have decayed after 50,000 years, the carbon isotope ratio is mainly useful for dating [fossils](#) and artifacts younger than this. It cannot be used to determine the age of Earth, for example.

carnivorous: Feeding largely or exclusively on meat or other animal tissue.

Carroll, Sean: Developmental geneticist with the Howard Hughes Medical Institute and professor at the University of Wisconsin-Madison. From the large-scale changes that distinguish major animal groups to the finely detailed color patterns on butterfly wings, Dr. Carroll's research has centered on those genes that create the "molecular blueprint" for body pattern and play major roles in the origin of new features. Coauthor, with Jennifer Grenier and Scott Weatherbee, of *From DNA to Diversity: Molecular Genetics and the Evolution of Animal Design*.

Carson, Rachel: A scientist and writer fascinated with the workings of nature. Her best-known publication, *Silent Spring*, was written over the years 1958 to 1962. The book looks at the effects of insecticides and pesticides on songbird populations throughout the United States. The publication helped set off a wave of environmental legislation and galvanized the emerging ecological movement.

Castle, W.E.: An early experimental [geneticist](#), his 1901 paper was the first on [Mendelism](#) in America. His *Genetics of Domestic Rabbits*, published in 1930 by Harvard University Press, covers such topics as the [genes](#) involved in determining the coat colors of rabbits and associated [mutations](#).

cell: The basic structural and functional unit of most living organisms. Cell size

varies, but most cells are microscopic. Cells may exist as independent units of life, as in bacteria and protozoans, or they may form colonies or tissues, as in all plants and animals. Each cell consists of a mass of protein material that is differentiated into [cytoplasm](#) and nucleoplasm, which contains DNA. The cell is enclosed by a cell membrane, which in the cells of plants, fungi, algae, and bacteria is surrounded by a cell wall. There are two main types of cell, [prokaryotic](#) and [eukaryotic](#).

Cenozoic: The era of geologic time from 65 mya to the present, a time when the modern continents formed and modern animals and plants evolved.

centromere: A point on a [chromosome](#) that is involved in separating the copies of the chromosome produced during cell division. During this division, paired chromosomes look somewhat like an X, and the centromere is the constriction in the center.

cephalopod: Cephalopods include squid, octopi, cuttlefish, and chambered nautilus. They are [mollusks](#) with tentacles and move by forcing water through their bodies like a jet.

character: Any recognizable trait, feature, or property of an organism.

character displacement: The increased difference between two closely related [species](#) where they live in the same geographic region ([sympatry](#)) as compared with where they live in different geographic regions ([allopatry](#)). Explained by the relative influences of intra- and inter-specific competition in sympatry and allopatry.

chloroplast: A structure (or [organelle](#)) found in some cells of plants; its function is photosynthesis.

cholera: An acute infectious disease of the small intestine, caused by the [bacterium](#) *Vibrio cholerae* which is transmitted in drinking water contaminated by feces of a patient. After an incubation period of 1-5 days, cholera causes severe vomiting and diarrhea, which, if untreated, leads to dehydration that can be fatal.

chordate: A member of the [phylum](#) Chordata, which includes the [tunicates](#), lancelets, and [vertebrates](#). They are animals with a hollow dorsal nerve cord; a rodlike [notochord](#) that forms the basis of the internal skeleton; and paired gill slits in the wall of the pharynx behind the head, although in some chordates these are apparent only in early [embryonic](#) stages. All vertebrates are chordates, but the phylum also contains simpler types, such as sea-squirts, in which only the free-swimming [larva](#) has a notochord.

chromosomal inversion: See [inversion](#).

chromosome: A structure in the cell [nucleus](#) that carries [DNA](#). At certain times in the cell cycle, chromosomes are visible as string-like entities. Chromosomes consist of the DNA with various [proteins](#), particularly histones, bound to it.

chronology: The order of events according to time.

Clack, Jenny: A paleontologist at Cambridge University in the U.K., Dr. Clack studies the origin, [phylogeny](#), and [radiation](#) of early [tetrapods](#) and their relatives among the lobe-finned fish. She is interested in the timing and sequence of skeletal and other changes which occurred during the transition, and the origin and relationships of the diverse tetrapods of the late Paleozoic.

clade: A set of [species](#) descended from a [common ancestral](#) species. Synonym of [monophyletic group](#).

cladism: [Phylogenetic](#) classification. The members of a group in a cladistic classification share a more recent [common ancestor](#) with one another than with the members of any other group. A group at any level in the classificatory hierarchy, such as a [family](#), is formed by combining a subgroup at the next lowest level (the [genus](#), in this case) with the subgroup or subgroups with which it shares its most recent common ancestor. Compare with [evolutionary classification](#) and [phenetic classification](#).

cladistic species concept: The concept of species, according to which a species is a [lineage](#) of populations between two phylogenetic branch points (or speciation events). Compare with [biological species concept](#), [ecological species concept](#), [phenetic species concept](#), and [recognition species concept](#).

cladists: Evolutionary biologists who seek to classify Earth's life forms according to their evolutionary relationships, not just overall similarity.

cladogram: A branching diagram that illustrates hypotheses about the evolutionary relationships among groups of organisms. Cladograms can be considered as a special type of [phylogenetic tree](#) that concentrates on the order in which different groups branched off from their common ancestors. A cladogram branches like a family tree, with the most closely related species on adjacent branches.

class: A category of taxonomic classification between order and phylum, a class comprises members of similar orders. See taxon.

classification: The arrangement of organisms into hierarchical groups. Modern biological classifications are [Linnaean](#) and classify organisms into species, genus, family, order, class, phylum, kingdom, and certain intermediate categoric levels. [Cladism](#), [evolutionary classification](#), and [phenetic classification](#) are three methods of classification.

cline: A geographic gradient in the frequency of a [gene](#), or in the average value of a [character](#).

clock: See molecular clock.

clone: A set of genetically identical organisms [asexually reproduced](#) from one ancestral organism.

coadaptation: Beneficial interaction between (1) a number of genes at different loci within an organism, (2) different parts of an organism, or (3) organisms belonging to different species.

codon: A triplet of [bases](#) (or nucleotides) in the [DNA](#) coding for one [amino acid](#). The relation between codons and amino acids is given by the [genetic code](#). The triplet of bases that is complementary to a codon is called an anticodon; conventionally, the triplet in the [mRNA](#) is called the codon and the triplet in the tRNA is called the anticodon.

coelacanth: Although long thought to have gone extinct about 65 million years ago, one of these deep-water, lungless fish was caught in the 1930s. Others have since been caught and filmed in their natural habitat.

coevolution: Evolution in two or more species, such as predator and its prey or a [parasite](#) and its host, in which evolutionary changes in one species influence the evolution of the other species.

cognitive: Relating to cognition, the mental processes involved in the gathering, organization, and use of knowledge, including such aspects as awareness, perception, reasoning, and judgement. The term refers to any mental "behaviors" where the underlying characteristics are abstract in nature and involve insight, expectancy, complex rule use, imagery, use of symbols, belief, intentionality, problem-solving, and so forth.

common ancestor: The most recent ancestral form or species from which two different species evolved.

comparative biology: The study of patterns among more than one species.

comparative method: The study of [adaptation](#) by comparing many species.

concerted evolution: The tendency of the different genes in a [gene family](#) to evolve in concert; that is, each gene locus in the family comes to have the same genetic variant.

conodont: A jawless fish that had tiny, tooth-like phosphate pieces that are abundant in the fossil record, these were the earliest known [vertebrates](#).

continental drift: The process by which the continents move as part of large plates floating on Earth's mantle. See [plate tectonics](#).

contrivance: An object or characteristic used or modified to do something different from its usual use.

convergence: The process by which a similar character evolves independently in two species. Also, a synonym for [analogy](#); that is, an instance of a convergently evolved character, or a similar character in two species that was not present in their common ancestor. Examples include wings (convergent in birds, bats, and insects) and camera-type eyes (convergent in vertebrates and cephalopod mollusks).

convergent evolution: The evolution of species from different taxonomic groups toward a similar form; the development of similar characteristics by taxonomically different organisms.

Conway Morris, Simon: Paleobiologist and professor in the Department of

Earth Sciences at Cambridge University in the U.K. His research centers around the early evolution of the [metazoans](#), and he is a leading authority on Cambrian and Precambrian fossils. Conway Morris established a link between the Ediacaran fossils, a Burgess Shale fernlike frond *Thaumaptilon*, and the modern seapens, colonial animals related to the corals.

Cope's rule: The evolutionary increase in body size over geological time in a lineage of populations.

coral (also, rugose coral, tabulate coral): These tiny animals make calcium carbonate skeletons that are well known as a key part of tropical reefs. The skeletons of the extinct rugose and tabulate corals are known from fossils.

cranium: The part of the skull that protects the brain in vertebrates.

creationism: The religious doctrine that all living things on Earth were created separately, in more or less their present form, by a supernatural creator, as stated in the Bible; the precise beliefs of different creationist groups vary widely. See [separate creation](#).

creation science: An assortment of many different, non-scientific attempts to disprove evolutionary theory, and efforts to prove that the complexity of living things can be explained only by the action of an "intelligent designer."

Cretaceous: The final geological period of the Mesozoic era that began 144 million years ago and ended 65 million years ago. The end of this period is defined most notably by the extinction of the dinosaurs in one of the largest mass extinctions ever to strike the planet.

crinoid: A marine invertebrate animal belonging to a class (Crinoidea; about 700 species) of [echinoderms](#), including sea lilies and feather stars. They have a small cup-shaped body covered with hard plates and five radiating pairs of feathery flexible arms surrounding the mouth at the top. Sea lilies, most of which are extinct, are fixed to the sea bottom or some other surface such as a reef by a stalk. Feather stars are free-swimming and are usually found on rocky bottoms. Crinoids occur mainly in deep waters and feed on microscopic [plankton](#) and detritus caught by the arms and conveyed to the mouth. The larvae are sedentary. They arose in the Lower Ordovician (between 500 and 460 million years ago), and [fossil](#) crinoids are an important constituent of Palaeozoic limestones.

crossing over: The process during [meiosis](#) in which the [chromosome](#) of a [diploid](#) pair exchange genetic material, visible in the light microscope. At a genetic level, it produces [recombination](#).

crustacean: A group of marine invertebrates with exoskeletons and several pairs of legs. They include shrimp, lobsters, crabs, amphipods (commonly known as "sand fleas"), and many more.

Currie, Cameron: A Canadian ecologist and recipient of the 2001 Natural Sciences and Engineering Research Council Doctoral Prize for his research on the complex symbiotic relationship of fungus-growing ants, the fungi they cultivate, mutualistic bacteria that the ants carry on their bodies, and

pathogens that attack the fungi.

cytoplasm: The region of a [eukaryotic cell](#) outside the nucleus.

Daeschler, Ted: Paleontologist and associate research curator at the Academy of Natural Sciences. Discoverer of late Devonian limbed fossils *Hynerpeton basseti* and *Designathus rowei* ([tetrapods](#)) and *Sauripterus taylorii* and *Hyneria* (lobed-finned fishes), all early examples of animals exploiting both land and water environments. Author of two books on [paleontology](#) for young people.

Dart, Raymond: Australian-born South African anatomist and anthropologist (1893-1988). In 1924 he described a fossil skull collected near Taung in South Africa, naming it *Australopithecus africanus*. Dart asserted that the skull was intermediate between the apes and humans, a controversial claim at the time, though later work made it clear that the Taung child, as it came to be known, was indeed a [hominid](#).

Darwinian evolution: Evolution by the process of natural selection acting on random variation.

Darwinism: Darwin's theory that species originated by evolution from other species and that evolution is mainly driven by natural selection. Differs from [neo-Darwinism](#) mainly in that Darwin did not know about [Mendelian inheritance](#).

Darwin, Charles: The 19th-century naturalist considered the father of evolution. His landmark work, *On the Origin of Species*, published in 1859, presented a wealth of facts supporting the idea of evolution and proposed a viable theory for how evolution occurs -- via the mechanism Darwin called "natural selection." In addition to his prolific work in biology, Darwin also published important works on coral reefs and on the geology of the Andes, and a popular travelogue of his five-year voyage aboard HMS *Beagle*.

Darwin, Erasmus: The name shared by Charles Darwin's grandfather and brother, each important in his life and work. Charles's grandfather Erasmus (1731-1802) was a glorious polymath -- physician, author, and botanist. His impact is reflected throughout a wide range of disciplines from the poetry to the technology of his day. Author of *The Loves of the Plants*, a 2,000-line poem detailing their sexual reproduction, and *Zoonomia, or the Theory of Generations*, whose themes echo throughout his grandson's work. Charles's older brother Erasmus (1805-1881), known as "Ras," used his network of social and scientific contacts to advance the theories of his shy, more retiring sibling.

Dawkins, Richard: An evolutionary biologist who has taught zoology and is the author of several books on evolution and science, including *The Selfish Gene* (1976) and *The Blind Watchmaker* (1986). He is known for his popularization of Darwinian ideas, as well as for original thinking on evolutionary theory.

Dembski, William: A mathematician and philosopher who has written on [intelligent design](#), attempting to establish the legitimacy and fruitfulness of design within biology.

Dennett, Daniel: Philosopher and director of the Center for Cognitive Studies at Tufts University, whose work unites neuroscience, computer science, and evolutionary biology. Dennett sees no basic distinction between human and machine intelligence, advocating a mechanical explanation of consciousness. He is the author of *Brainchildren: Essays on Designing Minds* and *Darwin's Dangerous Idea: Evolution and the Meanings of Life*, among many other books and publications.

derived homology: [Homology](#) that first evolved in the common ancestor of a set of species and is unique to those species. Compare with [ancestral homology](#).

de facto: In fact; in reality. Something which exists or occurs de facto is not the result of a law, but because of circumstances.

diatom: These single-celled algae are common among the marine [phytoplankton](#). Their glassy, two-part shells have intricate patterns and fit together like the two parts of a shirt box.

diffusion: The process by which molecules (for example, of oxygen) move passively from a region of high concentration to a region of low concentration.

dinoflagellate: Possessing two tail-like extensions called flagella that are used for movement, these single-celled algae can live freely or in other organisms such as [corals](#). When many dinoflagellates suddenly reproduce in great numbers, they create what are known as "red tides" by making the water appear red.

diploid: Having two sets of [genes](#) and two sets of [chromosomes](#) (one from the mother, one from the father). Many common species, including humans, are diploid. Compare with [haploid](#) and [polyploid](#).

directional selection: Selection causing a consistent directional change in the form of a population through time (e.g., selection for larger body size).

disruptive selection: Selection favoring forms that deviate in either direction from the population average. Selection favors forms that are larger or smaller than average, but works against the average forms between the extremes.

distance: In [taxonomy](#), referring to the quantitatively measured difference between the [phenetic](#) appearance of two groups of individuals, such as populations or species (phenetic distance), or the difference in their gene frequencies (genetic distance).

DNA: Deoxyribonucleic acid, the molecule that controls inheritance.

DNA base sequence: A chain of repeating units of deoxyribonucleotides (adenine, guanine, cytosine, thymine) arranged in a particular pattern.

Dobzhansky, Theodosius: A geneticist and zoologist best known for his research in [population genetics](#) using the fruit fly. His study of the evolution of races led to the discovery of genetic diversity within species, and confirmed his belief that genetic variation leads to better adaptability.

dominance (genetic): An [allele](#) (A) is dominant if the phenotype of the [heterozygote](#) (Aa) is the same as the [homozygote](#) (AA). The allele (a) does not influence the heterozygote's phenotype and is called [recessive](#). An allele may be partly, rather than fully, dominant; in that case, the heterozygous [phenotype](#) is nearer to, rather than identical with, the homozygote of the dominant allele.

drift: Synonym of [genetic drift](#).

duplication: The occurrence of a second copy of a particular sequence of DNA. The duplicate sequence may appear next to the original or be copied elsewhere into the [genome](#). When the duplicated sequence is a [gene](#), the event is called gene duplication.

echinoderm: Echinoderms, whose name means "spiny skin," are a group of marine invertebrates that includes starfish, brittlestars, basket stars, sea cucumbers, sand dollars, sea urchins, and others. They live in environments from shallow coastal waters to deep-sea trenches, from the tropics to the poles.

ecological genetics: The study of evolution in action in nature, by a combination of field work and laboratory genetics.

ecological species concept: A concept of species, according to which a species is a set of organisms adapted to a particular, discrete set of resources (or "[niche](#)") in the environment. Compare with [biological species concept](#), [cladistic species concept](#), [phenetic species concept](#), and [recognition species concept](#).

ecosystem: A community of organisms interacting with a particular environment.

Eldredge, Niles: A paleontologist and evolutionary biologist with the American Museum of Natural History, Eldredge, together with [Stephen Jay Gould](#), proposed the theory of punctuated equilibria, providing paleontologists with an explanation for the patterns which they find in the fossil record. He has written several books for a general audience, including *Time Frames: The Evolution of Punctuated Equilibria* and *Life in the Balance: Humanity and the Biodiversity Crisis*.

electrophoresis: The method of distinguishing entities according to their motility in an electric field. In evolutionary biology, it has been mainly used to distinguish different forms of proteins. The electrophoretic motility of a molecule is influenced by its size and electric charge.

embryo: An early stage of animal development that begins after division of the zygote (the earliest stage, in which joined egg and sperm have not yet divided).

embryonic: Related to an [embryo](#), or being in the state of an [embryo](#).

emigration: The movement of organisms out of an area.

Emlen, Stephen: A world authority on the social behavior of animals, particularly birds. Emlen's interests center on evolutionary or adaptive aspects

of animal behavior. The goal of his research is to better understand the social interactions that occur between individuals, especially cooperation and conflict.

empirical: Determined by experimentation.

Endler, John: A zoologist and professor with interests in evolution and how it affects geographic variation. His current research focuses on guppies (*Poecilia reticulata*) in their natural habitat, and how visual signs and vision dictate their behavior.

enzyme: A protein that acts as a catalyst for chemical reactions.

Eocene: The second oldest of the five major epochs of the Tertiary period, from 54 to 38 mya. It is often known for the rise of mammals.

epistasis: An interaction between the [genes](#) at two or more [loci](#), such that the [phenotype](#) differs from what would be expected if the loci were expressed independently.

Erwin, Douglas: Dr. Erwin is a paleobiologist with the National Museum of Natural History in the Smithsonian Institution. His research is concerned with aspects of major evolutionary novelties, particularly the Metazoan [radiation](#) and post-mass extinction recoveries. Recent work has involved the developmental events associated with the Cambrian along with their environmental context. He also works on the rate, causes and consequences of the end-Permian mass [extinction](#).

eugenics: The science or practice of altering a population, especially of humans, by controlled breeding for desirable inherited characteristics. The term was coined in 1883 by Francis Galton, who was an advocate of "improving" the human race by modifying the fertility of different categories of people. Eugenics fell into disfavor after the perversion of its doctrines by the Nazis.

eukaryote: Any organism made up of [eukaryotic cells](#). Eukaryotes are generally larger and have more DNA than [prokaryotes](#) (whose cells do not have a nucleus to contain their DNA). Almost all multicellular organisms are eukaryotes.

eukaryotic cell: A cell with a distinct [nucleus](#).

evolution: Darwin defined this term as "descent with modification." It is the change in a lineage of populations between generations. In general terms, biological evolution is the process of change by which new species develop from preexisting species over time; in genetic terms, evolution can be defined as any change in the frequency of alleles in populations of organisms from generation to generation.

evolutionary classification: Method of classification using both [cladistic](#) and [phenetic](#) classificatory principles. To be exact, it permits [paraphyletic](#) groups (which are allowed in phenetic but not in cladistic classification) and [monophyletic](#) groups (which are allowed in both cladistic and phenetic classification) but excludes [polyphyletic](#) groups (which are banned from cladistic classification but permitted in phenetic classification).

Ewald, Paul: Professor of biology at Amherst College, specializing in hummingbird and flower coevolution and the evolution of infectious diseases. His research on disease focuses on the evolutionary effects of various public health interventions.

exon: The [nucleotide](#) sequences of some genes consist of parts that code for [amino acids](#), with other parts that do not code for amino acids interspersed among them. The coding parts, which are translated, are called exons; the interspersed non-coding parts are called [introns](#).

extinction: The disappearance of a species or a population.

fact: A natural phenomenon repeatedly confirmed by observation.

family: The category of taxonomic classification between order and genus (see [taxon](#)). Organisms within a family share a close similarity; for example, the cat family, Felidae, which includes lions and domestic cats.

fauna: Animal life; often used to distinguish from plant life ("flora").

fermentation: A series of reactions occurring under anaerobic conditions (lacking oxygen) in certain microorganisms (particularly yeasts) in which organic compounds such as glucose are converted into simpler substances with the release of energy. Fermentation is involved in bread making where the carbon dioxide produced by the yeast causes dough to rise.

fetus: The [embryo](#) of a mammal that has reached a stage of development in the uterus in which most of the adult features are recognizable. Specifically in humans it refers to the stage of development after the appearance of bone cells, a process occurring 7 to 8 weeks after fertilization.

fitness: The success of an individual (or [allele](#) or [genotype](#) in a population) in surviving and reproducing, measured by that individual's (or allele's or genotype's) genetic contribution to the next generation and subsequent generations.

FitzRoy, Robert: Captain of the *Beagle*, which took Charles Darwin on his famous voyage to South America and around the world. FitzRoy's chief mission on the *Beagle* was to chart the coast of South America. He also established the first weather warning system while on his journeys, with the help of the telegraph, and later rose to the rank of Admiral in the British Navy. He was known as a young man for his moody temperament, and in his older age for questionable sanity, FitzRoy's life ended in suicide.

fixation: A gene has achieved fixation when its frequency has reached 100 percent in the population.

fixed: (1) In [population genetics](#), a gene is "fixed" when it has a frequency of 100 percent. (2) In [creationism](#), species are described as "fixed" in the sense that they are believed not to change their form, or appearance, through time.

Flammer, Larry: A retired high school biology teacher and co-founder of the Santa Clara County Biotechnology-Education Partnership, which provides

teacher training and lab equipment for local schools. He is a current member and Web writer for the Evolution and Nature of Science Institute (ENSI).

flora: Plant life; often used to distinguish from animal life ("fauna").

foraminifera: These invertebrates are very common in the global ocean, and their distinctive, chambered shells are common in the fossil record as far back as 550 million years. Although very few today exceed 9 mm in diameter, fossils have been found that measure 15 cm across.

fossil: Most commonly, an organism, a physical part of an organism, or an imprint of an organism that has been preserved from ancient times in rock, amber, or by some other means. New techniques have also revealed the existence of cellular and molecular fossils.

founder effect: The loss of genetic variation when a new colony is formed by a very small number of individuals from a larger population.

frequency-dependent selection: Selection in which the fitness of a genotype (or phenotype) depends on its frequency in the population.

fungi: A group of organisms comprising the kingdom Fungi, which includes molds and mushrooms. They can exist either as single cells or make up a multicellular body called a mycelium. Fungi lack chlorophyll and secrete digestive enzymes that decompose other biological tissues.

Galton, Francis: A cousin of Charles Darwin, Galton was a British explorer and anthropologist. He was known for his studies of human intelligence and later for his work in eugenics (a term he coined), the "science" of improving human hereditary characteristics. Known for his efforts at various sorts of measurement (he developed fingerprinting and was a pioneer in statistics), he was knighted in 1909.

gamete: Haploid reproductive cells that combine at fertilization to form the zygote, called sperm (or pollen) in males and eggs in females.

gastropod: Meaning "stomach foot," this name refers to the class of mollusks that contains the most species. Gastropods include snails and slugs that are marine, freshwater, and terrestrial.

Gehring, Walter J.: Dr. Gehring and his research group discovered the homeobox, a DNA segment characteristic for homeotic genes which is not only present in arthropods and their ancestors, but also in vertebrates up to humans. Their work on the "master control gene" for eye development sheds light on how the mechanism for building eyes may have evolved long ago in the ancestor of what are now very different types of organisms.

gene: A sequence of nucleotides coding for a protein (or, in some cases, part of a protein); a unit of heredity.

genetic: Related to genes. A gene is a sequence of nucleotides coding for a protein (or, in some cases, part of a protein); a unit of heredity.

genetics: The study of genes and their relationship to characteristics of organisms.

genetic code: The code relating [nucleotide triplets](#) in the mRNA (or DNA) to amino acids in the proteins.

genetic distance: See [distance](#).

genetic drift: Changes in the frequencies of [alleles](#) in a population that occur by chance, rather than because of [natural selection](#).

genetic engineering: Removing genes from the DNA of one species and splicing them into the DNA of another species using the techniques of molecular biology.

genetic load: A reduction in the average fitness of the members of a population because of the deleterious genes, or gene combinations, in the population. It has many particular forms, such as "mutational load," "segregational load," and "recombinational load."

genetic locus: See [locus](#).

gene duplication: See [duplication](#).

gene family: A set of related genes occupying various [loci](#) in the DNA, almost certainly formed by [duplication](#) of an ancestral gene and having a recognizably similar sequence. Members of a gene family may be functionally very similar or differ widely. The globin gene family is an example.

gene flow: The movement of genes into or through a population by interbreeding or by migration and interbreeding.

gene frequency: The frequency in the population of a particular gene relative to other genes at its [locus](#). Expressed as a proportion (between 0 and 1) or percentage (between 0 and 100 percent).

gene pool: All the genes in a population at a particular time.

genome: The full set of [DNA](#) in a cell or organism.

genomics: The study that characterizes genes and the [traits](#) they encode.

genotype: The set of two genes possessed by an individual at a given [locus](#). More generally, the genetic profile of an individual.

genus (plural genera): The second-to-lowest category in taxonomic classification. The phrase "species name" generally refers to the genus and species together, as in the Latin name for humans, *Homo sapiens*. See [taxon](#).

geographic isolation: See [reproductive isolation](#).

geographic speciation: See [allopatric speciation](#).

geologic time: The time scale used to describe events in the history of Earth.

germination: The initial stages in the growth of a seed to form a seedling. The embryonic shoot (plumule) and embryonic root (radicle) emerge and grow upward and downward, respectively. Food reserves for germination come from tissue within the seed and/or from the seed leaves (cotyledons).

germ plasm: The reproductive cells in an organism, or the cells that produce the [gametes](#). All cells in an organism can be divided into the soma (the cells that ultimately die) and the germ cells (the cells that are perpetuated by reproduction).

gestation: The period in animals bearing live young (especially mammals) from the fertilization of the egg and its implantation into the wall of the uterus until the birth of the young (parturition), during which the young develops in the uterus. In humans gestation is known as pregnancy and takes about nine months (40 weeks).

Gingerich, Philip: Gingerich is interested in evolutionary change documented in the fossil record and how this relates to the kinds of changes observable in the field or laboratory on the scale of a few generations. His ongoing fieldwork in Wyoming, Egypt, and Pakistan is concerned with the origin of modern orders of mammals, especially primates and whales.

glaciation: The formation of large sheets of ice across land. Glaciation of the continents marks the beginning of ice ages, when the makeup of Earth and organisms on it changes dramatically.

Goldfarb, Alex: A Russian-born microbiologist now at the Public Health Research Institute in New York City, Dr. Goldfarb is piloting a program in the Russian prison system to combat the further evolution of drug-resistant strains of tuberculosis, which have infected at least 30,000 inmates.

Gould, Stephen Jay: A professor of geology and zoology at Harvard University since 1967. A paleontologist and an evolutionary biologist, he teaches geology and the history of science, as well. With others, he has advanced the concept that major evolutionary changes can occur in sudden bursts rather than through the slow, gradual process proposed by the traditional view of evolution. In addition to his scholarly works, Gould has published numerous popular books on paleoanthropology, Darwinian theory, and evolutionary biology.

Grant, Peter and Rosemary: Biologists whose long-term research focuses on finches in the Galapagos Islands, and the evolutionary impact of climatic and environmental changes on their populations. They live part of the year in the Islands, and have received honors for their work since they began in 1973.

graptolite: A small, colonial, often [planktonic](#) marine animal that was very abundant in the oceans 300 to 500 million years ago; now extinct.

Greene, Mott: A historian of science who has written extensively about the development of geological thought during the 19th and early 20th centuries, including the development of the theory of continental drift.

greenhouse gases: Gases that absorb and reradiate infrared radiation. When present in the atmosphere, these gases contribute to the greenhouse effect, trapping heat near the surface of the planet. On Earth, the main greenhouse gases are carbon dioxide, water vapor, methane, nitrous oxide, ozone, and some halocarbon compounds.

group selection: The selection operating between groups of individuals rather than between individuals. It would produce attributes beneficial to a group in competition with other groups rather than attributes beneficial to individuals.

Haeckel, Ernst: A German biologist who lived from 1834-1919, Haeckel was the first to divide animals into protozoan (unicellular) and metazoan (multicellular) forms. His notion of [recapitulation](#) is no longer accepted.

Haile Selassie, Yohannes: A paleoanthropologist who, while doing field work in Ethiopia for his doctoral dissertation at the University of California, Berkeley, discovered *Ardipithecus ramidus kadabba*, a bipedal hominid dated at 5.2 million years old.

half-life: The amount of time it takes for one-half of the atoms of a radioactive material to decay to a stable form. For example, the half-life of carbon-14 is 5,568 years.

Hamilton, W.D.: A naturalist, explorer, and zoologist who worked in the world of mathematical models, including "Hamilton's Rule," about the spread through a population of a gene for altruistic self sacrifice. He was also interested in the evolutionary impact of [parasites](#) as the key to many outstanding problems left by Darwin, including the baffling riddle of the evolution of sex. This led him to extensive work in computer simulations.

haploid: The condition of having only one set of genes or chromosomes. In normally diploid organisms such as humans, only the gametes are haploid.

haplotype: A set of genes at more than one [locus](#) inherited by an individual from one of its parents. It is the multi-locus analog of an [allele](#).

Hardy-Weinberg principle: In population genetics, the idea that if a population experienced no selection, no [mutation](#), no migration, no [genetic drift](#), and random mating, then the frequency of each [allele](#) and the frequencies of [genotype](#) in the population would remain the same from one generation to the next.

Hardy-Weinberg ratio: The ratio of genotype frequencies that evolve when mating is random and neither selection nor drift are operating. For two alleles (A and a) with frequencies p and q, there are three genotypes: AA, Aa, and aa. The Hardy-Weinberg ratio for the three is: $p^2AA : 2pqAa : q^2aa$. It is the starting point for much of the theory of population genetics.

Harvey, Ralph: A geologist whose work includes the study of geological processes at a range of scales, from the smallest nanometer to broader-scale interpretations of the history experienced by geological materials.

heavy metals: Metals with a high relative atomic mass, such as lead, copper, zinc and mercury. Many of them are toxic.

hemoglobin: A protein that carries oxygen from the lungs throughout the body.

heredity: The process by which characteristics are passed from one generation to the next.

heritability: Broadly, the proportion of variation (more strictly, variance) in a phenotypic character in a population that is due to individual differences in [genotypes](#). Narrowly, it is defined as the proportion of variation (more strictly, variance) in a [phenotypic character](#) in a population that is due to individual genetic differences that will be inherited in the offspring.

heritable: Partly or wholly determined by genes; capable of being passed from an individual to its offspring.

Herrnstein, Richard J.: A professor of psychology and an author of notable books on intelligence and crime. He has primarily done research on human and animal motivational and learning processes. His books include *Psychology and I. Q. in the Meritocracy*, and he coauthored (with Charles Murray) *The Bell Curve: Intelligence and Class Structure in American Life* (1994).

heterogametic: The sex with two different sex [chromosomes](#) (males in mammals, because they are XY). Compare with [homogametic](#).

heterozygosity: (for most purposes) The proportion of individuals in a population that are heterozygotes.

heterozygote: An individual having two different [alleles](#) at a genetic [locus](#). Compare with [homozygote](#).

heterozygote advantage: A condition in which the [fitness](#) of a [heterozygote](#) is higher than the fitness of either [homozygote](#).

heterozygous: Having two different alleles for a particular trait. See also [heterozygote](#).

Hill, Andrew: A paleontologist and professor at Yale University. His work with Mary Leakey's team at Laetoli, Tanzania, in the 1970s helped lead to the discovery of the fossilized footprints of early [hominids](#) and other mammals. His current research interests include hominid evolution, paleoecology and taphonomy.

HIV: Human Immunodeficiency Virus. The virus causes AIDS by inactivating the T cells of the immune system.

homeobox: Homeoboxes are relatively short, very similar or identical sequences of [DNA](#), characteristic of homeotic genes (which play a central role in controlling body development) and shared by almost all [eukaryotic](#) species. Homeoboxes encode a [protein](#) "homeodomain", a protein domain that binds to DNA. The DNA-binding homeodomain consists of approximately 60 [amino acids](#),

and these homeodomain motifs are involved in orchestrating the development of a wide range of organisms.

homeobox genes: A set of [genes](#) that are important in developmental patterns. These establish segments in an [embryo](#) that may become specific organs or tissue types. In general, "homeotic" genes are genes that control the development of organisms, and "homeogenes" or "homeobox genes" are the subset of homeotic genes that contain "[homeoboxes](#)". "Hox" genes are a subset of homeogenes that determine positional cell differentiation and development. [Mutations](#) in Hox genes result in the conversion of one body part into another: for example, in the fruit fly *Drosophila*, a specific Hox mutation results in a leg developing where an antenna would normally be.

homeostasis (developmental): A self-regulating process in development, such that the organism grows up to have much the same form independent of the external influences it experiences while growing up.

homeotic mutation: A [mutation](#) causing one structure of an organism to grow in the place appropriate to another. For example, in the mutation called "antennapedia" in the fruit fly, a foot grows in the antennal socket.

hominids: Members of the family Hominidae, which includes only modern humans and their ancestors since the human lineage split from the apes.

homogametic: The sex with two of the same kind of [chromosomes](#) (females in mammals, because they are XX). Compare with [heterogametic](#).

homologous structures: The structures shared by a set of related species because they have been inherited, with or without modification, from their common ancestor. For example, the bones that support a bat's wing are similar to those of a human arm.

homology: A [character](#) shared by a set of species and present in their common ancestor. Compare with analogy. (Some molecular biologists, when comparing two sequences, call the corresponding sites "homologous" if they have the same nucleotide, regardless of whether the similarity is evolutionarily shared from a common ancestor or convergent. They likewise talk about percent homology between the two sequences. Homology in this context simply means similarity. This usage is frowned upon by many evolutionary biologists, but is established in much of the molecular literature.)

homozygote: An individual having two copies of the same [allele](#) at a genetic [locus](#). Also sometimes applied to larger genetic entities, such as a whole chromosome; a homozygote is then an individual having two copies of the same chromosome.

homozygous: Having identical [alleles](#) for a particular trait. See also [homozygote](#).

***Homo erectus*:** A species of [hominid](#) that lived between 1.8 mya and 300,000 years ago; the first *Homo* species to migrate beyond Africa.

***Homo habilis*:** A species of [hominid](#) that lived between 1.9 and 1.8 mya, the

first species in genus *Homo*, and the first hominid associated with clear evidence of tool manufacture and use.

***Homo neanderthalensis*:** A species of [hominid](#) that lived between 150,000 and 30,000 years ago in Europe and Western Asia, originally thought to be a geographic variant of *Homo sapiens* but now generally accepted to be a distinct species.

***Homo sapiens*:** Modern humans, which evolved to their present form about 100,000 years ago.

horsetail: A seedless plant related to ferns. Twenty-five [species](#) of only one [genus](#), *Equisetum*, remain today, whereas many different species, some the size of modern trees, were abundant in ancient swamps. Along with [lycophytes](#) and ferns, horsetails were among the first [terrestrial](#) plants to appear.

Ho, David: A physician and world-renowned AIDS researcher. Dr. Ho overturned an earlier conventional assumption that the HIV virus remains dormant for up to 10 years in a person before its outbreak into AIDS. His recognition that the virus is active right from the beginning of infection led him to initiate the deployment of a combination of drugs to overpower the virus.

Huxley, Thomas Henry: British intellect, photographer, and contemporary of Darwin. He was the first to apply the theory of natural selection to humanity to explain the course of human evolution.

hybrid: The offspring of a cross between two species.

hypothesis: An explanation of one or more phenomena in nature that can be tested by observations, experiments, or both. In order to be considered scientific, a hypothesis must be falsifiable, which means that it can be proven to be incorrect.

idealism: The philosophical theory that there are fundamental non-material "ideas," "plans," or "forms" underlying the phenomena we observe in nature. It has been historically influential in classification.

immigration: The movement of organisms into an area.

immutability: The ability to withstand change.

induction: The process of deriving general principles from particular facts.

inference: A conclusion drawn from evidence.

inheritance of acquired characters: Historically influential but factually erroneous theory that an individual inherits characters that its parents [acquired](#) during their lifetimes.

insectivorous: Feeding largely or exclusively on insects.

intelligent design: The non-scientific argument that complex biological structures have been designed by an unidentified supernatural or

extraterrestrial intelligence.

intron: The [nucleotide](#) sequences of some genes consist of parts that code for amino acids, and other parts that do not code for amino acids interspersed among them. The interspersed non-coding parts, which are not translated, are called introns; the coding parts are called [exons](#).

inversion: An event (or the product of the event) in which a sequence of [nucleotides](#) in the [DNA](#) is reversed, or inverted. Sometimes inversions are visible in the structure of the chromosomes.

IQ: An abbreviation of "intelligence quotient," usually defined as the mental age of an individual (as measured by standardized tests) divided by his or her real age and multiplied by 100. This formulation establishes the average IQ as 100. The usefulness and reliability of IQ as a measure of intelligence has been questioned, in part because of the difficulty of devising standardized tests that are free of cultural biases.

isolating mechanism: Any mechanism, such as a difference between species in courtship behavior or breeding season, that results in [reproductive isolation](#) between the species.

isolation: Synonym for [reproductive isolation](#).

isotope: An atom that shares the same atomic number and position as other atoms in an element but has a different number of neutrons and thus a different atomic mass.

Jablonski, David: [Paleontologist](#) and professor in the Department of the Geophysical Sciences of the University of Chicago. His research emphasizes combining data from living and [fossil](#) organisms to study the origins and fates of [lineages](#) and [adaptations](#), to develop an understanding of the underlying dynamics of [speciation](#) and [extinction](#) that could lead to a general theory of evolutionary novelty. He is interested in the way evolutionary patterns are shaped by the alternation of extinction regimes, with rare but influential mass extinctions driving unexpected evolutionary shifts.

Johanson, Don: A paleontologist and founder of the Institute for Human Origins. Johanson discovered [Lucy](#) (at that time the oldest, most complete [hominid](#) skeleton known) in 1974, and the following year unearthed the fossilized remains of 13 early hominids in Ethiopia. He is the author of several popular books on human origins.

Johnson, Jerry: Johnson's research interests focus on the interactions and evolutionary relationships of amphibian and reptilian species of tropical American and Mexican desert ecosystems. Johnson specializes in field research in places such as Yucatan, Jalisco, Zacatecas, and Chiapas, Mexico. He has done research on the biochemical analysis of rattlesnake venom using immunological techniques, snake ecology, and lizard ecology.

Johnston, Victor: Professor of biopsychology at New Mexico State University in Las Cruces. His research interests include the evolution of consciousness and perceptions of beauty. He is the author of *Why We Feel: the Science of Human*

Emotions.

Kegl, Judy: A linguist who works on theoretical linguistics as it applies to signed and spoken languages. Among her research interests is a study of Nicaraguan Sign Language.

Kimbel, Bill: An anatomist, Kimbel worked with Don Johanson and assembled Lucy's skull fragments. In 1991, Kimbel and Yoel Rak found a 70 percent complete skeleton of *Australopithecus afarensis*.

kingdom: The second highest level of taxonomic classification of organisms (below domains). Classification schemes at the kingdom level have changed over time. Recent molecular data have generally reinforced the evolutionary significance of the kingdoms Animalia, Plantae, and Fungi. The single-celled eukaryotes once lumped into the kingdom Protista are now known to be very diverse, and not closely related to one another. The prokaryotic organisms once lumped into the kingdom Monera are now considered to belong to separate domains: Eubacteria and Archaea. see [taxon](#).

Kirchweger, Gina: An Austrian biologist interested in the biological evolution of skin tone. Her essay, "The Biology of Skin Color," concerns the evolution of race.

Kluger, Matthew: A researcher whose work on lizards demonstrated that fever is beneficial and can improve the immune response to infection. The implication for humans is still being researched, but evidence indicates that mild fevers can have a number of important immunological functions that allow us to better fight bacterial and viral infections.

Knowlton, Nancy: Dr. Knowlton is Professor of Marine Biology at the Scripps Institution of Oceanography, University of California San Diego, and Staff Scientist at the Smithsonian Tropical Research Institute in Panama. Her primary research interests concern various facets of marine [biodiversity](#). These include the nature of [species](#) boundaries in [corals](#), elucidating [biogeographic](#) patterns in tropical seas, the ecology of coral-algal [symbiosis](#), and threshold effects in coral reef ecosystems.

Kondrashov, Alexey: A population geneticist specializing in mathematical analysis who has studied the evolutionary role of slightly deleterious [mutations](#). He has theorized that a primitive organism's strategy for protecting itself against damaging mutations may have been the first step in the evolution of sexual reproduction.

Kreiswirth, Barry: Director of the Public Health Research Institute TB Center in New York, Dr Kreiswirth uses DNA fingerprinting to study the evolution of [antibiotic resistance](#) in *Mycobacterium tuberculosis*, the [pathogen](#) that causes [TB](#).

Lamarckian inheritance: Historically misleading synonym for [inheritance of acquired characteristics](#).

Lamarck, Jean: An 18th-century naturalist, zoologist, and botanist noted for his study and classification of invertebrates, as well as his evolutionary theories. He traveled extensively throughout Europe and was elected to the

Academy of Sciences, where he introduced the principles of heredity and [acquired characteristics](#).

land bridge: A connection between two land masses, especially continents (e.g., the Bering land bridge linking Alaska and Siberia across the Bering Strait) that allows migration of plants and animals from one land mass to the other. Before the widespread acceptance of [continental drift](#), the existence of former land bridges was often invoked to explain [faunal](#) and [floral](#) similarities between continents now widely separated. On a smaller scale, the term may be applied to land connections that have now been removed by recent tectonics or sea-level changes (e.g., between northern France and southeastern England).

larva (and larval stage): The prereproductive stage of many animals. The term is particularly apt when the immature stage has a different form from the adult. For example, a caterpillar is the larval stage of a butterfly or moth.

law: A description of how a natural phenomenon will occur under certain circumstances.

Leakey, Maeve: A paleoanthropologist at the National Museums of Kenya, Maeve is the discoverer of *Kenyanthropus platyops* and *Australopithecus anamensis*. She is married to Richard Leakey.

Leakey, Mary: A British paleoanthropologist described as "a real fossil hunter" and "the real scientist in the family." Her discoveries, some in collaboration with her husband Louis Leakey, included the 1.75-million-year-old skull which first showed the antiquity of [hominids](#) in Africa, jaws and teeth of an early *Homo* species, and fossilized footprints of [bipedal](#) hominids.

Leakey, Richard: The son of renowned anthropologists Louis and [Mary Leakey](#), Richard continued their work on early [hominids](#) from 1964 until the 1980s, making a number of significant fossil finds in the Lake Turkana area and serving as Director of the National Museum of Kenya. Later he devoted his energies to conservation and politics.

Lee, Melanie: A molecular geneticist and microbial biologist, who in the 1980s collaborated with Paul Nurse on novel research that demonstrated the commonality of the genetic code between yeasts and humans. Dr Lee later took her molecular skills into the pharmaceutical industry, and was a leader in moving pharmacology away from animal models and towards the use of recombinant DNA technology for screening potential new therapies. She now heads the research division of Celltech, an international biopharmaceutical company, where her team works on drug discovery and development of new therapies, mainly for the treatment of inflammatory and immune diseases.

lek: An area of ground divided into territories that are defended by males for the purpose of displaying to potential mates during the breeding season. This form of mating behaviour is known as lekking, and occurs in various bird species (for example the peacock) and also in some mammals. The dominant males occupy the territories at the centre of the lek, where they are most likely to attract and mate with visiting females. The outer territories are occupied by subordinate males, who have less mating success. Over successive breeding seasons, younger subordinate males tend to gradually displace older individuals

from the most desirable territories and become dominant themselves. The lek territories do not contain resources of value to the female, such as food or nesting materials, although males of some species may build structures such as bowers that form part of their display.

lemur: A small, tree-dwelling primate that belongs to the group called [prosimians](#).

lethal recessive: The case in which inheriting two recessive [alleles](#) of a [gene](#) causes the death of the organism.

Levine, Michael: Professor of Genetics and Development in the Molecular and Cell Biology Department at University of California, Berkeley. Discoverer (with [Bill McGinnis](#)) of [homeobox](#) sequences in the homeotic genes *Antennapedia* and *Ultrabithorax* while a postdoctoral researcher with [Walter Gehring](#) at the University of Basel, Switzerland. His current research involves analysis of gene regulation and patterning in the early *Drosophila* [embryo](#); studies of embryonic development in the [tunicate](#), *Ciona intestinalis*, focused on the specification of the [notochord](#) and tail muscles; and a critical test of classical models for the evolutionary origins of the [chordate](#) body plan.

lineage: An ancestor-descendant sequence of (1) populations, (2) cells, or (3) genes.

linkage disequilibrium: A condition in which the [haplotype](#) frequencies in a population deviate from the values they would have if the genes at each locus were combined at random. (When no deviation exists, the population is said to be in linkage equilibrium.)

linked: Of genes, present on the same chromosome.

Linnaean classification: A hierarchical method of naming classificatory groups, invented by the eighteenth century Swedish naturalist Carl von Linné, or Linnaeus. Each individual is assigned to a species, genus, family, order, class, phylum, and kingdom, and some intermediate classificatory levels. Species are referred to by a Linnaean binomial of its genus and species, such as *Magnolia grandiflora*.

Lively, Curtis: A professor of biology who studies population biology and the ecology and evolution of host-[parasite](#) interactions. His laboratory is involved in detailed studies of the interaction between a parasitic trematode and a freshwater New Zealand snail in which both sexual and [asexual](#) females coexist.

locus: The location in the [DNA](#) occupied by a particular [gene](#).

Lovejoy, Owen: A [paleoanthropologist](#) and consulting forensic anatomist, Lovejoy is known for his analysis of early hominid fossils. His research includes work on Lucy (*Australopithecus afarensis*).

lycophyte: Commonly known as club mosses, lycophytes were among the first seedless plants to appear on Earth. Along with horsetails and ferns, these made the planet more hospitable for the first animals.

Lyell's notion of gradual change: Also called uniformitarianism, Lyell's notion was that Earth has been shaped by the same forces and processes that operate today, acting continuously over very long periods of time. For example, the ongoing erosion caused by flowing water in a river could, given enough time, carve out the Grand Canyon.

Lyell, Charles: A 19th-century scientist considered a father of modern geology. Lyell proposed that the geology of Earth is shaped by gradual processes, such as erosion and sedimentation. Lyell's ideas, expressed in his landmark work, *Principles of Geology*, greatly influenced the young Charles Darwin. Darwin and Lyell later became close friends. While Lyell initially opposed the idea of evolution, he came to accept it after Darwin published *On the Origin of Species*.

macroevolution: A vague term generally used to refer to evolution on a grand scale, or over long periods of time. There is no precise scientific definition for this term, but it is often used to refer to the emergence or modification of taxa at or above the genus level. The origin or adaptive radiation of a higher taxon, such as vertebrates, could be called a macroevolutionary event.

macromutation: [Mutation](#) of large [phenotypic](#) effect, one that produces a phenotype well outside the range of variation previously existing in the population.

malaria: A sometimes-fatal disease transferred to humans by mosquitoes, infecting the bloodstream.

Malthus, Thomas: A British economist and demographer best known for his treatise on population growth, which states that people will always threaten to outrun the food supply unless reproduction is closely monitored. His theory was in opposition to the utopians of the 18th century.

mammals: The group (specifically, a class) of animals, descended from a common ancestor, that share the derived characters of hair or fur, mammary glands, and several distinctive features of skeletal anatomy, including a particular type of middle ear. Humans, cows, and dolphins are all mammals.

mammary glands: Only found in mammals, these are specialized glands that can produce milk for feeding young.

mandible: A part of the bony structure of a jaw. In vertebrates, it is the lower jaw; in birds, the lower bill; in arthropods, one of the paired appendages closest to the mouth.

Margulis, Lynn: A biologist who developed the serial endosymbiosis theory of origin of the [eukaryotic cell](#). Although now accepted as a plausible theory, both she and her theory were ridiculed by mainstream biologists for a number of years.

marsupial mammals: A group (specifically, an order) of [mammals](#) whose females give birth to young at a very early stage of development. These newborns complete their development while sucking in a pouch, which is a permanent feature on the female. Examples include kangaroos and opossums.

mastodon: An extinct elephant-like mammal.

Mayr, Ernst: Mayr's work has contributed to the synthesis of Mendelian genetics and Darwinian evolution, and to the development of the [biological species concept](#). Mayr has been universally recognized and acknowledged as one of the leading evolutionary biologists of the 20th century.

McGinnis, William: Professor of Biology, University of California at San Diego. Discover (with [Mike Levine](#)) of [homeoboxes](#), the sequences of DNA that are characteristic of homeotic genes, which play a central role in specifying body development. His current research uses both genetics and biochemistry to examine such questions as how molecular variations in the Hox genes that specify the head-tail pattern of an organism can generate variety in animal shapes during evolution, and what the molecular changes were that allowed single celled animals to become multicellular.

meiosis: A special kind of cell division that occurs during the reproduction of [diploid](#) organisms to produce the [gametes](#). The double set of genes and chromosomes of the normal diploid cells is reduced during meiosis to a single [haploid](#) set in the gametes. [Crossing-over](#) and therefore [recombination](#) occur during a phase of meiosis.

mememe: The word coined by [Richard Dawkins](#) for a unit of culture, such as an idea, skill, story, or custom, passed from one person to another by imitation or teaching. Some theorists argue that memes are the cultural equivalent of [genes](#), and reproduce, mutate, are selected, and evolve in a similar way.

Mendelian inheritance: The mode of inheritance of all [diploid](#) species, and therefore of nearly all multicellular organisms. Inheritance is controlled by [genes](#), which are passed on to the offspring in the same form as they were inherited from the previous generation. At each [locus](#) an individual has two genes -- one inherited from its father and the other from its mother. The two genes are represented in equal proportions in its [gametes](#).

Mendel, Gregor: An Austrian monk whose plant breeding experiments, begun in 1856, led to insights into the mechanisms of heredity that are the foundation of genetics today. His work was ignored in his lifetime and only rediscovered in 1900. See [Mendelian inheritance](#).

messenger RNA (mRNA): A kind of [RNA](#) produced by [transcription](#) from the DNA and which acts as the message that is decoded to form [proteins](#).

metabolism: The chemical processes that occur in a living organism in order to maintain life. There are two kinds of metabolism: constructive metabolism, or anabolism, the synthesis of the proteins, carbohydrates, and fats which form tissue and store energy; and destructive metabolism, or catabolism, the breakdown of complex substances, producing energy and waste matter.

metamorphosis: One or more changes in form during the life cycle of an organism, such as an [amphibian](#) or insect, in which the juvenile stages differ from the adult. An example is the transition from a tadpole to an adult frog. The term "complete metamorphosis" is applied to insects such as butterflies in

which the caterpillar stage is distinct from the adult. "Incomplete metamorphosis" describes the life histories of insects such as locusts in which the young go through a series of larval stages, each of which bears similarities to the adult. Metamorphosis in both insects and amphibians is controlled by hormones, and often involves considerable destruction of larval tissues by [enzymes](#).

metazoans: All animals that are multicellular and whose [cells](#) are organized into tissues and organs. In the simplest metazoans only an inner and outer layer can be distinguished.

microbe: A nonscientific and very general term, with no taxonomic significance, sometimes used to refer to microscopic (not visible to the unaided eye) organisms. The term often refers to bacteria or viruses that cause disease or infection.

microevolution: Evolutionary changes on the small scale, such as changes in gene frequencies within a population.

Miller, Geoffrey: Author of *The Mating Mind*, Miller is known for his research on evolutionary psychology and sexual selection. He believes that our minds evolved not only as survival machines, but also as courtship machines -- at least in part, to help us attract a mate and pass on genes.

Miller, Ken: A cell biologist and professor of biology at Brown University. Miller's academic research focuses on the structure and function of biological membranes. He is the coauthor of widely used high school and college biology textbooks, and he has also written *Finding Darwin's God: A Scientist's Search for Common Ground Between God and Evolution*.

Miller, Veronica: A German virologist whose research has focused on HIV-AIDS. Miller was the first researcher to announce that an interruption in drug treatment among AIDS patients may result in reversion of drug-resistant virus to its [wild type](#). This led other researchers and clinicians to explore "structured treatment interruptions" among some patients as an experimental treatment option.

mimicry: A case in which one species looks more or less similar to another species. See [Batesian mimicry](#) and [Müllerian mimicry](#).

mitochondrial DNA: [DNA](#) found in the [mitochondrion](#), a small round body found in most cells. Because mitochondria are generally carried in egg cells but not in sperm, mitochondrial DNA is passed to offspring from mothers, but not fathers.

mitochondrion: A kind of [organelle](#) in [eukaryotic cells](#). Mitochondria produce [enzymes](#) to convert food to energy. They contain DNA coding for some mitochondrial proteins.

mitosis: Cell division. All cell division in multicellular organisms occurs by mitosis except for the special division called [meiosis](#) that generates the gametes.

Müllerian mimicry: A kind of [mimicry](#) in which two poisonous species evolve to

look like one another.

modern synthesis: The synthesis of [natural selection](#) and [Mendelian inheritance](#). Also called [neo-Darwinism](#).

molecular clock: The theory that molecules evolve at an approximately constant rate. The difference between the form of a molecule in two species is then proportional to the time since the species diverged from a [common ancestor](#), and molecules become of great value in the inference of [phylogeny](#).

molecular geneticists: Scientists who study [genes](#) and [characters](#) through work with the molecules that make up and interact with [DNA](#).

mollusk: An invertebrate that has a fleshy, muscular body. The phylum Mollusca includes snails, bivalves, squids, and octopuses.

"monkey trial": In 1925, John Scopes was convicted and fined \$100 for teaching evolution in his Dayton, Tenn., classroom in the first highly publicized trial concerning the teaching of evolution. The press reported that although they lost the case, Scopes's team had won the argument. The verdict had a chilling effect on teaching evolution in the classroom, however, and not until the 1960s did it reappear in schoolbooks.

monogamy: A reproductive strategy in which one male and one female mate and reproduce exclusively with each other. Contrast with [polygyny](#) and [polyandry](#).

monophyletic group: A set of species containing a common ancestor and all of its descendants, and not containing any organisms that are not the descendants of that common ancestor.

monotreme: Egg-laying mammals.

monotremes: A group (specifically, an order) of mammals whose females lay eggs. The young hatch and continue to develop in the mother's pouch, which is present only when needed. Two species of spiny anteater and the duck-billed platypus are the only living monotremes.

Moore, James: The author, with Adrian Desmond, of an authoritative biography of Charles Darwin, Moore has made a 20-year study of Darwin's life. With degrees in science, divinity, and history, he has taught the history of science at Harvard University and at the Open University in the U.K.

morphology: The study of the form, shape, and structure of organisms.

Mueller, Ulrich G.: A zoologist and professor whose research aims at understanding microevolutionary forces and macroevolutionary patterns that govern the evolution of organismal interactions, particularly the evolution of mutualisms and the evolution of social conflict and cooperation. Mueller's current research focuses on the coevolution between fungus-growing ants and their fungi and the evolutionary ecology of halictine bees.

Murray, Charles: An author and policy analyst who has written many

controversial and influential books on social policy. He is coauthor with Richard J. Herrnstein of *The Bell Curve: Intelligence and Class Structure in American Life* (1994). He has also written *Losing Ground: American Social Policy 1950-1980* (1984), which argues for the abolishment of the welfare system, *The Underclass Revisited* (1999), and *Income, Inequality and IQ* (1998).

mutation: A change in genetic material that results from an error in replication of [DNA](#). Mutations can be beneficial, harmful, or neutral.

Nagel, Ronald: A hematologist and professor at Albert Einstein College of Medicine. His research includes molecular, biochemical, and physiological studies of genetic red blood cell defects, including [sickle cell](#).

natural selection: The differential survival and reproduction of classes of organisms that differ from one another in one or more usually heritable characteristics. Through this process, the forms of organisms in a population that are best adapted to their local environment increase in frequency relative to less well-adapted forms over a number of generations. This difference in survival and reproduction is not due to chance.

Neanderthal: A [hominid](#), similar to but distinct from modern humans, that lived in Europe and Western Asia about 150,000 to 30,000 years ago.

Nelson, Craig: A professor of biology and environmental affairs at Indiana University in Bloomington. His research focuses on evolutionary ecology.

neo-Darwinism: (1) Darwin's theory of natural selection plus Mendelian inheritance. (2) The larger body of evolutionary thought that was inspired by the unification of natural selection and Mendelism. A synonym of the [modern synthesis](#).

nervous system: An organ system, composed of a network of cells called neurons, that allows an animal to monitor its internal and external environment, and to move voluntarily or in response to stimulation.

neural: Related to nerves and neurons.

neutral drift: Synonym of [genetic drift](#).

neutral mutation: A [mutation](#) with the same [fitness](#) as the other [allele](#) or alleles at its [locus](#).

neutral theory (and neutralism): The theory that much evolution at the molecular level occurs by [genetic drift](#).

Newton, Isaac: An English physician and mathematician, considered the culminating figure of the scientific revolution of the 17th century. He is best known for his explanation of gravity and for laying the foundation for modern physical optics.

niche: The ecological role of a species; the set of resources it consumes and habitats it occupies.

Nilsson, Dan-Erik: Professor Nilsson heads the Functional Morphology Division of the Department of Zoology at Lund University in Sweden. His main research interest is the optics and evolution of invertebrate eyes.

Nilsson, Lennart: A Swedish photographer who began as a photojournalist, Nilsson soon began exploring new techniques such as the use of endoscopes and electron microscopes to photograph the inner mysteries of the human body. He published a book, *A Child is Born* of his photographs of the beginning of life, and made a number of films, including the mini-series *Odyssey of Life* a coproduction between WGBH/NOVA and SVT Swedish Television.

nitrogen fixation: A chemical process by which nitrogen in the atmosphere is assimilated into organic compounds. Only certain [bacteria](#) are able to fix atmospheric nitrogen, which then becomes available to other organisms through the food chains.

nomadic: Having to do with nomads, people who live in no fixed place but move in search of food or grazing land for their animals; of a wandering lifestyle.

notochord: A flexible skeletal rod running the length of the body in the [embryos](#) of the [chordates](#) (including the [vertebrates](#)). In some simpler types, such as sea-squirts, only the free-swimming [larva](#) has a notochord; in others, such as the lancelets and lampreys, the notochord remains the main axial support, and in vertebrates it is incorporated into the backbone as the embryo develops.

Novacek, Michael J.: Paleontologist with the American Museum of Natural History. Dr Novacek's research interests include evolution of and relationships among organisms, particularly [mammals](#). Author of *Dinosaurs of the Flaming Cliffs*, an account of AMNH's Gobi Desert Expeditions.

nucleotide: A unit building block of [DNA](#) and [RNA](#). A nucleotide consists of a sugar and phosphate backbone with a [base](#) attached.

nucleus: A region of [eukaryotic cells](#), enclosed within a membrane, containing the [DNA](#).

numerical taxonomy: In general, any method of [taxonomy](#) using numerical measurements. In particular, it often refers to [phenetic classification](#) using large numbers of quantitatively measured [characters](#).

Nurse, Paul: A pioneer in genetic and molecular studies who revealed the universal machinery for regulating cell division in all [eukaryotic](#) organisms, from yeasts to frogs to human beings.

O'Brien, Stephen J.: A geneticist at the National Cancer Institute whose research interests include the evolutionary history of the immunological response in mammals to retroviruses like HIV. With his colleagues, he discovered a mutation that can protect individuals from infection by HIV, the virus that causes AIDS.

order: The taxonomic classification level between class and family. For example, within the class Mammalia, there are several orders, including the

meat-eaters, who make up the order Carnivora; and the insect-eaters, grouped together in the order Insectivora. The orders in turn are divided into families; the order Carnivora includes the families Felidae (the cats), Canidae (the dogs), and Ursidae (the bears), among others. See also [taxon](#).

organelle: Any of a number of distinct small structures found in the cytoplasm (and therefore outside the nucleus) of [eukaryotic cells](#) (e.g., [mitochondrion](#) and [chloroplast](#)).

organisms: Living things.

orthogenesis: The erroneous idea that species tend to evolve in a fixed direction because of some inherent force driving them to do so.

Owen, Richard: A 19th-century British comparative anatomist, who coined the word "dinosaur" to describe a breed of large, extinct reptiles. He was the first to propose that dinosaurs were a separate taxonomic group. Owen opposed Darwin's theory of evolution, but ultimately his work helped support evolutionary arguments.

ozone layer: The region of the atmosphere, generally 11-26 km (7-16 miles) above Earth, where ozone forms in high concentrations. The ozone layer absorbs ultraviolet radiation, shielding Earth from its damaging effects.

paleoanthropologist: A scientist who uses [fossil](#) evidence to study early human ancestors.

paleobiology: The biological study of [fossils](#).

paleontologist: A scientist who studies [fossils](#) to better understand life in prehistoric times.

paleontology: The scientific study of [fossils](#).

Pangaea: A supercontinent which began to break apart into the modern continents about 260 million years ago, causing the isolation (and separate evolution) of various groups of organisms from each other.

panmixis: Random mating throughout a population.

paradox: A seemingly absurd or contradictory, though often true, statement.

parapatric speciation: Speciation in which the new species forms from a population contiguous with the ancestral species' geographic range.

paraphyletic group: A set of species containing an ancestral species together with some, but not all, of its descendants. The species included in the group are those that have continued to resemble the ancestor; the excluded species have evolved rapidly and no longer resemble their ancestor.

parasite: An organism that lives on or in a plant or animal of a different species, taking nutrients without providing any benefit to the host.

Parish, Amy: A biological anthropologist and primatologist whose research focuses on the social behavior of bonobos ("pygmy chimpanzees," or *Pan paniscus*). In addition to comparative work with chimpanzees (*Pan troglodytes*) and endocrinological investigations, Dr. Parish studies reciprocity in chimpanzees, bonobos, and hunter-gatherers.

parsimony: The principle of [phylogenetic](#) reconstruction in which the phylogeny of a group of species is inferred to be the branching pattern requiring the smallest number of evolutionary changes.

parthenogenesis: Development from an egg cell that has not been fertilized. The term for a certain form of [asexual reproduction](#) that is found in some lizards, insects (notably among aphids), and certain other organisms.

particulate: (as property of theory of inheritance) A synonym of [atomistic](#).

paternity: The identity of the father of an offspring.

pathogen: A microorganism that causes disease.

pathological: Related to or caused by disease.

penicillin: The first antibiotic discovered, penicillin is derived from the mold *Penicillium notatum*. It is active against a wide variety of bacteria, acting by disrupting synthesis of the bacterial cell wall.

peripatric speciation: A synonym of [peripheral isolate speciation](#).

peripheral isolate speciation: A form of [allopatric speciation](#) in which the new species is formed from a small population isolated at the edge of the ancestral population's geographic range. Also called [peripatric speciation](#).

pesticide-resistant insects: Insects with the ability to survive and reproduce in the presence of pesticides. These resistant variants increase in frequency over time if pesticides remain present in their environment.

Petrie, Marion: A behavioural ecologist at the University of Newcastle in the UK, Dr Petrie's research interests include the links between [sexual selection](#) and [speciation](#), and how males and females assess genetic quality in a mate.

phenetic classification: A method of classification in which species are grouped together with other species that they most closely resemble [phenotypically](#).

phenetic species concept: A concept of species according to which a species is a set of organisms that are [phenotypically](#) similar to one another. Compare with [biological species concept](#), [cladistic species concept](#), [ecological species concept](#), and [recognition species concept](#).

phenotype: The physical or functional characteristics of an organism, produced by the interaction of [genotype](#) and environment during growth and development.

phenotypic characters: Individual traits that can be observed in an organism (including appearance and behavior) and that result from the interaction between the organism's genetic makeup and its environment.

pheromone: A chemical substance produced by some [organisms](#) and emitted into the environment to communicate with others of the same [species](#). Pheromones play an important role in the social behavior of certain animals, especially insects and some [mammals](#). They are used to mark out territories, to attract mates, to lay trails, and to promote social cohesion and coordination in colonies. Examples are the sex attractants secreted by moths to attract mates and the queen substance produced by queen honeybees, which controls the development and behavior of worker bees. Pheromones are usually volatile organic molecules which are effective at very low concentrations, as little as 1 part per million.

photoreceptor cell: A cell, functionally part of the nervous system, that reacts to the presence of light. It usually contains a pigment that undergoes a chemical change when light is absorbed. This chemical change stimulates electrical changes in the photoreceptor that, when passed along and processed by other neurons, form the basis of vision.

photosynthesis: The fundamental biological process by which green plants make organic compounds such as carbohydrates from atmospheric carbon dioxide and water using light energy from the Sun. The process has two main phases: the light-dependent light reaction responsible for the initial capture of energy, and the light-independent dark reaction in which this energy is stored in the chemical bonds of organic molecules. Since virtually all other forms of life are directly or indirectly dependent on green plants for food, photosynthesis is the basis for almost all life on earth.

phylogeny: The study of ancestral relations among species, often illustrated with a "tree of life" branching diagram, which is also known as a phylogenetic tree.

phylum (plural phyla): One of the highest levels of taxonomic classification. See [taxon](#).

phytoplankton: Microscopic aquatic organisms that, like plants, use photosynthesis to capture and harness solar energy.

Pickford, Martin: A paleontologist at the College de France in Paris. In 2000, Pickford and Brigitte Senut discovered *Orrorin tugenensis*, a proto-hominid dated at 6 million years old.

Pinker, Steven: A psychologist and professor with a special interest in language, linguistic behavior, and cognitive science. Pinker's publications include the popular science books *The Language Instinct* and *How the Mind Works*.

placental mammals: A group (specifically, an order) of mammals in which the young develop inside the mother, attached to her and nourished by a specialized structure called the placenta. In placental mammals, the young are born in an advanced stage of development. Compare with [marsupial](#) and

[monotreme](#).

placoderm: An extinct bottom-dwelling fish that was among the first to develop jaws and paired fins.

plankton: Minute or microscopic animals (zooplankton) and plants (phytoplankton) that float and drift in water, usually near the surface. In the top meter or two of water, both in the sea and in freshwater, small plants can photosynthesize, and abundant microscopic life can be observed. Many organisms that are sessile (attached to a surface) as adults disperse by means of a planktonic [larval](#) stage.

plan of nature: The philosophical theory that nature is organized according to a plan. It has been influential in classification, and is a kind of [idealism](#).

plasmid: A genetic element that exists (or can exist) independently of the main DNA in the cell. In bacteria, plasmids can exist as small loops of DNA and be passed between cells independently.

plate tectonics: The theory that the surface of the earth is made of a number of plates, which have moved throughout geological time resulting in the present-day positions of the continents. Plate tectonics explains the locations of mountain building as well as earthquakes and volcanoes. The rigid plates consist of continental and oceanic crust together with the upper mantle, which "float" on the semi-molten layer of the mantle beneath them, and move relative to each other across the earth. Six major plates (Eurasian, American, African, Pacific, Indian, and Antarctic) are recognized, together with a number of smaller ones. The plate margins coincide with zones of seismic and volcanic activity.

Poisson distribution: A frequency distribution for number of events per unit time, when the number of events is determined randomly and the probability of each event is low.

polyandry: A reproductive system in which one female mates with many males. Seahorses and jacanas are examples of polyandrous species, which are less common than [monogamous](#) or [polygynous](#) species.

polygyny: Reproductive strategy in which one male mates with several females. Lions, peacocks, and gorillas all have polygynous mating systems. Compare with [polyandry](#) and [monogamy](#).

polymorphism: A condition in which a population possesses more than one [allele](#) at a [locus](#). Sometimes it is defined as the condition of having more than one allele with a frequency of more than five percent in the population.

polyphyletic group: A set of species descended from more than one [common ancestor](#). The ultimate common ancestor of all species in the group is not a member of the polyphyletic group.

polyploid: An individual containing more than two sets of [genes](#) and [chromosomes](#).

population: A group of organisms, usually a group of sexual organisms that interbreed and share a [gene pool](#).

population genetics: The study of processes influencing gene frequencies.

postulate: A basic principle.

postzygotic isolation: A form of [reproductive isolation](#) in which a [zygote](#) is successfully formed but then either fails to develop or develops into a sterile adult. Donkeys and horses are postzygotically isolated from one another; a male donkey and a female horse can mate to produce a mule, but the mule is sterile.

prezygotic isolation: A form of [reproductive isolation](#) in which the two species never reach the stage of successful mating, and thus no [zygote](#) is formed. Examples would be species that have different breeding seasons or courtship displays, and which therefore never recognize one another as potential mates.

primate: A [mammal](#) belonging to the order Primates (about 195 species), which includes prosimians, monkeys, apes, and humans. Primates probably evolved from [insectivorous](#) climbing creatures like tree shrews and have many adaptations for climbing, including five fingers and five toes with opposable first digits (except in the hind feet of humans). They have well-developed hearing and sight, with forward-facing eyes allowing binocular vision, and large brains. The young are usually produced singly and undergo a long period of growth and development to the adult form. Most primates are [arboreal](#), but the great apes and humans are largely terrestrial.

prokaryote: A cell without a distinct nucleus. Bacteria and some other simple organisms are prokaryotic. Compare with [eukaryote](#). In classificatory terms, the group of all prokaryotes is [paraphyletic](#).

prosimian: One of the group of [primates](#) that includes lemurs and lorises; the other two primate groups are tarsoids and anthropoids.

protein: A molecule made up of a sequence of [amino acids](#). Many of the important molecules in a living thing -- for example, all enzymes -- are proteins.

protozoa: A group of unicellular, usually microscopic, organisms now classified in various phyla of the [kingdom](#) Protocista. They were formerly regarded either as a phylum of simple animals or as members of the kingdom Protista. Most feed on decomposing dead organic matter, but some are parasites, including the agents causing malaria (*Plasmodium*) and sleeping sickness (*Trypanosoma*), and a few contain chlorophyll and carry out [photosynthesis](#), like plants.

pseudogene: A sequence of nucleotides in the DNA that resembles a [gene](#) but is nonfunctional for some reason.

pupa (plural pupae): The third stage of development in the life cycle of some insects, including flies, butterflies (in which it is the chrysalis), ants, bees, and beetles. During the pupal stage locomotion and feeding cease and

metamorphosis from the **larva** to the adult form takes place. The adult emerges by cutting or digesting the pupal case after a few days or several months.

purine: A kind of **base** in the DNA; adenine (A) and guanine (G) are purines.

pyrimidine: A kind of **base**. In DNA, cytosine (C) and thymine (T) are pyrimidines. In RNA, cytosine (C) and uracil (U) are pyrimidines.

quantitative character: A **character** showing continuous variation in a population.

radioactivity: The emission of energy due to changes in the nucleus of an atom. Such spontaneously released radiation is a characteristic of certain elements and at some levels can be harmful.

radiometric dating: A dating technique that uses the decay rate of radioactive **isotopes** to estimate the age of an object.

Rak, Yoel: An Israeli paleoanthropologist and anatomist whose research interests include facial **morphology** of fossil **hominids**. Rak was part of the team that found a 2.3-million-year-old skull fragment from the genus *Homo* at Hadar, Ethiopia.

random drift: Synonym of **genetic drift**.

random mating: A mating pattern in which the probability of mating with another individual of a particular **genotype** (or **phenotype**) equals the frequency of that genotype (or phenotype) in the population.

recanted: Withdrew a statement or opinion; disavowed a former assertion.

recapitulation: A partly or wholly erroneous hypothesis stating that an individual, during its development, passes through a series of stages corresponding to its successive evolutionary ancestors. According to the recapitulation hypothesis, an individual thus develops by "climbing up its family tree."

receptors: **Proteins** that can bind to other specific molecules. Usually on the surface of a cell, receptors often bind to antibodies or hormones.

recessive: An **allele** (A) is recessive if the **phenotype** of the **heterozygote** (Aa) is the same as the **homozygote** (aa) for the alternative allele (a) and different from the homozygote for the recessive (AA). The allele (a) controls the heterozygote's phenotype and is called **dominant**. An allele may be partly, rather than fully, recessive; in that case, the heterozygous phenotype is nearer to, rather than identical with, the homozygote for the dominant allele.

recognition species concept: A concept of species according to which a species is a set of organisms that recognize one another as potential mates; they have a shared mate recognition system. Compare with **biological species concept**, **cladistic species concept**, **ecological species concept**, and **phenetic species concept**.

recombination: An event, occurring by the [crossing-over](#) of [chromosomes](#) during [meiosis](#), in which DNA is exchanged between a pair of chromosomes of a pair. Thus, two genes that were previously unlinked, being on different chromosomes, can become [linked](#) because of recombination, and linked genes may become unlinked.

reinforcement: An increase in [reproductive isolation](#) between incipient species by [natural selection](#). Natural selection can directly favor only an increase in prezygotic isolation; reinforcement therefore amounts to selection for [assortative mating](#) between the incipiently speciating forms.

relative dating: The process of ordering fossils, rocks, and geologic events from oldest to youngest. Because of the way sedimentary rocks form, lower layers in most series are older than higher layers, making it possible to determine which fossils found in those layers are oldest and which are youngest. By itself, relative dating cannot assign any absolute age to rocks or fossils.

reproductive character displacement: The increased reproductive isolation between two closely related species when they live in the same geographic region ([sympatry](#)) as compared with when they live in separate geographic regions. A kind of [character displacement](#) in which the character concerned influences reproductive isolation, not ecological competition.

reproductive isolation: Two populations or individuals of opposite sex are considered reproductively isolated from one another if they cannot together produce fertile offspring. See [prezygotic isolation](#) and [postzygotic isolation](#).

retina: The back wall of the eye onto which images are projected. From the retina, the information is sent to the brain via the optic nerve.

ribosomal RNA (rRNA): The kind of [RNA](#) that constitutes the ribosomes and provides the site for translation.

ribosome: The site of protein synthesis (or [translation](#)) in the cell, mainly consisting of [ribosomal RNA](#).

ring species: A situation in which two reproductively isolated populations (see [reproductive isolation](#)) living in the same region are connected by a geographic ring of populations that can interbreed.

RNA: Ribonucleic acid. [Messenger RNA](#), [ribosomal RNA](#), and [transfer RNA](#) are its three main forms. These act as the intermediaries by which the hereditary code of DNA is converted into proteins. In some viruses, RNA is itself the hereditary molecule.

Saag, Michael: Dr. Saag is director of the AIDS Outpatient Clinic and Associate Professor of Medicine at the University of Alabama, Birmingham. He is also associate director for clinical care and therapeutics at the UAB AIDS Center. Dr. Saag's research activities focus on both clinical and basic aspects of the human immunodeficiency virus. He serves on several state and national advisory panels, including the NIH/NIAID AIDS Clinical Trials Group Executive Committee.

sagittal crest: A ridge of bone projecting up from the top midline of the skull, running from front to back. It serves as a muscle attachment area for the muscles that extend up the side of the head from the jaw. The presence of a sagittal crest indicates extremely strong jaw muscles.

Schneider, Chris: A biologist and professor at Boston University whose research focuses on the evolution of vertebrate diversity in tropical systems and the scientific basis for conservation of tropical diversity. He uses a variety of molecular genetic methods, such as DNA sequencing, to study speciation, systematics, and biogeography of terrestrial vertebrates, with an emphasis on reptiles and amphibians.

Schultz, Ted R.: An ant systematist at the Smithsonian Institution, Dr. Schultz studies the evolution of the symbiosis between fungus-growing ants and the fungi they cultivate.

science: A way of knowing about the natural world based on observations and experiments that can be confirmed or disproved by other scientists using accepted scientific techniques.

Scopes, John: The 24-year-old teacher in the public high school in Dayton, Tenn., who was the defendant in the "monkey trial" of 1925. He agreed to be the focus of a test case attacking a newly passed Tennessee state law against teaching evolution or any other theory denying the biblical account of the creation of man, and was arrested and tried, with the American Civil Liberties Union backing his defense.

Scott, Eugenie C.: A human biologist specializing in medical anthropology and skeletal biology. As executive director of the National Center for Science Education, Scott is an advocate of church/state separation in schools, and speaks widely about science, evolution, and natural selection.

Scott, Matthew P.: A professor and researcher whose work in developmental biology explores how [homeotic genes](#) orchestrate differentiation and multicellular organization.

sedimentary rocks: Rocks composed of sediments, usually with a layered appearance. The sediments are composed of particles that come mostly from the weathering of pre-existing rocks, but often include material of organic origin; they are then transported and deposited by wind, water, or glacial ice. Sedimentary rocks are deposited mainly under water, usually in approximately horizontal layers (beds). Clastic sedimentary rocks are formed from the erosion and deposition of pre-existing rocks and are classified according to the size of the particles. Organically formed sedimentary rocks are derived from the remains of plants and animals, for example limestone and coal. Chemically formed sedimentary rocks result from natural chemical processes and include sedimentary iron ores. Many sedimentary rocks contain fossils.

selection: Synonym of [natural selection](#).

selectionism: The theory that some class of evolutionary events, such as molecular or [phenotypic](#) changes, have mainly been caused by [natural selection](#).

selective pressures: Environmental forces such as scarcity of food or extreme temperatures that result in the survival of only certain organisms with characteristics that provide resistance.

Senut, Brigitte: An anatomist at France's National Museum of Natural History. In 2000, Senut and Martin Pickford discovered *Orrorin tugenensis*, a proto-hominid dated at 6 million years old.

separate creation: The theory that species have separate origins and never change after their origin. Most versions of the theory of separate creation are religiously inspired and suggest that the origin of species occurs by [supernatural](#) action.

sexually dimorphic: When males and females of a species have considerably different appearances, which may include size, coloration, or other features, such as special plumage.

sexual selection: A selection on mating behavior, either through competition among members of one sex (usually males) for access to members of the other sex or through choice by members of one sex (usually females) of certain members of the other sex. In sexual selection, individuals are favored by their fitness relative to other members of the same sex, whereas [natural selection](#) works on the fitness of a [genotype](#) relative to the whole population.

sex chromosome: The [chromosome](#) or chromosomes that influence sex determination. In mammals, including humans, the X and Y chromosomes are the sex chromosomes (females are XX, males XY). Compare with [autosome](#).

Shubin, Neil: A paleontologist who is known for his work on early [tetrapods](#) (any creature with four limbs). He presented a hypothesis of general patterns of the development of tetrapod limbs which changed the way scientists think about this field. The study of limbs is crucial to evolutionary science; one example of why this is important is that human development would have been impossible without limbs.

sickle cell anemia: A disease in which poorly formed red blood cells cannot bind correctly to oxygen, resulting in low iron, blood clotting, and joint pain.

Simpson, George Gaylord: One of the most influential paleontologists of the 20th century and a leading developer of the [modern synthesis](#). He wrote hundreds of technical papers in addition to many widely read popular books and textbooks, and was a leading expert on Mesozoic, Paleocene, and South American mammals.

Small, Meredith: A professor of anthropology. Her research interests include primate behavior and ecology; mating strategies; reproduction; and the evolution of human behavior. Small's publications include *Female Choices: Sexual Behaviour of Female Primates*, *What's Love Got to Do With It?*, and *The Evolution of Human Mating*.

Smith, John Maynard: An eminent evolutionary biologist and author of many books on evolution, both for scientists and the general public. A professor

emeritus at the University of Sussex, his research interests include evolution of human [mitochondrial DNA](#) sequences and investigation of evidence for extensive [recombination](#).

Smith, Tom: An ornithologist and conservation biologist, Smith is executive director of the Center for Tropical Research at San Francisco State University. His work combines basic research in ecology and evolutionary science with applied research in conservation biology. Among other issues, Smith is interested in the role of ecological gradients in speciation and maintaining species diversity.

social Darwinism: A doctrine that applies the principles of selection to the structure of society, asserting that social structure is determined by how well people are suited to living conditions.

spacer region: A sequence of nucleotides in the DNA between coding [genes](#).

speciation: Changes in related organisms to the point where they are different enough to be considered separate species. This occurs when populations of one species are separated and adapt to their new environment or conditions (physiological, geographic, or behavioral).

species: An important classificatory category, which can be variously defined by the [biological species concept](#), [cladistic species concept](#), [ecological species concept](#), [phenetic species concept](#), and [recognition species concept](#). The biological species concept, according to which a species is a set of interbreeding organisms, is the most widely used definition, at least by biologists who study vertebrates. A particular species is referred to by a [Linnaean](#) binomial, such as *Homo sapiens* for human beings.

sponge: A member of the [phylum](#) Porifera, marine and freshwater invertebrates that live permanently attached to rocks or other surfaces. The body of a sponge is hollow and consists basically of an aggregation of [cells](#) between which there is little nervous coordination, although they do have specialized sets of cells that perform different functions. One set of cells causes water to flow in through openings in the body wall and out through openings at the top; food particles are filtered from the water by these cells. Other cells construct a stiffening skeletal framework of spicules of chalk, silica, or fibrous protein to support the body.

stabilizing selection: A form of selection that tends to keep the form of a population constant. Individuals with the mean value for a character have high [fitness](#); those with extreme values have low fitness.

stepped cline: A [cline](#) with a sudden change in gene or character frequency.

stromatoporoid: Stromatoporoids, once thought to be related to the [corals](#), are now recognized as being calcareous [sponges](#). Sponges similar to [fossil](#) stromatoporoids are found in the oceans today. Like modern sponges, stromatoporoid created currents to pump water in and out of their body, where they filtered out tiny food particles. Fossil stromatoporoids can be massive, chocolate-drop in shape, tabular, encrusting, cylindrical, or even arm-shaped ("ramose"). There are two main groups of fossil stromatoporoids that lived in

different eras, the Paleozoic and the Mesozoic. After their appearance in the Ordovician, the Paleozoic stromatoporoids were dominant reef builders for over 100 million years. The second group of stromatoporoids, from the Mesozoic, may represent a distinct group with a similar growth form. They were also important contributors to reef formation, especially during the Cretaceous.

subduction zone: A zone where rocks of an oceanic plate are forced to plunge below much thicker continental crust, along margins between adjoining plates. As the plate descends it melts and is released into the magma below the earth's crust. Such a zone is marked by volcanoes and earthquakes. See [plate tectonics](#).

substitution: The evolutionary replacement of one [allele](#) by another in a population.

supernatural: Relating to phenomena that cannot be described by natural laws, cannot be tested by scientific methodology, and are therefore outside the realm of science.

symbiosis: A relationship of mutual benefit between two organisms that live together.

sympatric speciation: Speciation via populations with overlapping geographic ranges.

sympatry: Living in the same geographic region. Compare with [allopatry](#).

syntax: The rules by which words are combined to form grammatical sentences.

systematics: A near synonym of [taxonomy](#).

tarsier: One of three species of small nocturnal [primate](#) belonging to the genus *Tarsius*, found in Sumatra, Borneo, Celebes, and the Philippines. They have a naked tail, 130-270 mm (about 5 - 11 inches) long, that makes up about half the total length of their bodies (220-460 mm or between 8 and 19 inches). Tarsiers have enormous eyes, large hairless ears, and gripping pads at the end of their digits. They are mainly [arboreal](#), using both hands to seize insects and small vertebrates such as lizards.

taxon (plural taxa): Any named taxonomic group, such as the family Felidae, or the genus *Homo*, or the species *Homo sapiens*. Also, a formally recognized group, as distinct from any other group (such as the group of herbivores, or the group of tree-climbers).

taxonomy: The theory and practice of biological [classification](#).

terrestrial: Living on land.

tetrapod: A member of the group made up of amphibians, reptiles, birds, and mammals.

thecodont: The thecodonts were a diverse group of Triassic reptiles that

included large four-legged carnivores, armored herbivores, small, agile two- and four-legged forms, and crocodile-like aquatic reptiles. They gave rise to crocodiles, dinosaurs, and pterosaurs. The term Thecodontia is no longer used, as they are a paraphyletic group. The thecodonts are therefore an evolutionary grade of animals, rather than a clade. Most palaeontologists now use the term "basal archosaur" to refer to thecodonts. As a group, they are defined by certain shared ancestral features, such as teeth in sockets, an archosaurian characteristic that was inherited by the dinosaurs. The name thecodont is actually Latin for "socket-tooth." Members of the group show a general trend toward a more upright, less sprawling stance, with the hindlimbs especially being progressively positioned more directly beneath the body, until some could walk upright on two legs.

theory: A well-substantiated explanation of some aspect of the natural world that typically incorporates many confirmed observations, laws, and successfully verified [hypotheses](#).

theropod: The theropod (meaning "beast-footed") dinosaurs are a diverse group of [bipedal](#) dinosaurs. They include the largest [terrestrial carnivores](#) ever to have lived, and many quite small [species](#). Theropods typically share a number of [traits](#) including hollow, thin-walled bones and modifications of the hands and feet (3 main fingers on the hand, and 3 main (weight-bearing) toes on the foot.) Most theropods had sharp, recurved teeth for eating flesh, and claws on the ends of all of the fingers and toes. Some of these characters were lost or modified in some groups later in theropod evolution. Theropod [fossils](#) are fairly rare and often fragmentary. Fossils of small theropods are especially rare, since small bones are harder to find and are weathered away easily.

Thiagarajan, Sivasailam: The president of Workshops by Thiagi, Inc., his organization helps people improve their performance through games and simulations.

trait: A characteristic or condition.

transcription: The process by which [messenger RNA](#) is read from the [DNA](#) forming a gene.

transfer RNA (tRNA): A type of [RNA](#) that brings the amino acids to the [ribosomes](#) to make proteins. There are 20 kinds of transfer RNA molecules, one for each of the 20 main amino acids. A transfer RNA molecule has an amino acid attached to it, and contains the anticodon corresponding to that amino acid in another part of its structure. In protein synthesis, each codon in the [messenger RNA](#) combines with the appropriate tRNA's anticodon, and the amino acids are arranged in order to make the protein.

transformism: The evolutionary theory of Lamarck in which changes occur within a [lineage](#) of populations, but in which lineages do not split (i.e., no speciation occurs, at least not in the sense of the [cladistic species concept](#)) and do not go extinct.

transition: A [mutation](#) changing one [purine](#) into the other purine, or one [pyrimidine](#) into the other pyrimidine (i.e., changes from A to G, or vice versa, and changes from C to T, or vice versa).

transitional fossil: A [fossil](#) or group of fossils representing a series of similar species, genera, or families, that link an older group of organisms to a younger group. Often, transitional fossils combine some traits of older, ancestral species with traits of more recent species (for instance, a series of transitional fossils documents the evolution of fully aquatic whales from terrestrial ancestors).

translation: The process by which a protein is manufactured at a [ribosome](#), using [messenger RNA](#) code and [transfer RNA](#) to supply the [amino acids](#).

transversion: A [mutation](#) changing a [purine](#) into a [pyrimidine](#), or vice versa (i.e., changes from A or G to C or T and changes from C or T to A or G).

trilobite: An extinct marine arthropod common from the Cambrian to Permian eras (570-245 million years ago). Trilobite fossils are abundant in rocks of this period. Trilobites were 10-675 mm long, and their flattened oval bodies were divided into three lobes by two longitudinal furrows. They had a single head shield, which bore a pair of antennae and in many species, insect-like compound eyes. This was followed by more than 20 short body segments, each with a pair of forked appendages. Many trilobites apparently burrowed in sand or mud, preying on other animals or scavenging.

tuberculosis: An infection of the lungs, accompanied by fever and a loss of appetite, caused by the bacillus *Mycobacterium tuberculosis*.

tunicate: A group of simple [chordates](#), including sea squirts (class Ascidae) that live attached to rocks, and the salps (class Thaliacea) that float in the sea. Tunicates are small marine animals, cylindrical, spherical, or irregular in shape, ranging from several millimetres to over 30 cm in size. They have a saclike cellulose tunic covering the body; water is drawn in through a siphon and food particles are filtered out. The free-swimming tadpole-like [larvae](#) show the major characteristics of all chordates. They subsequently undergo [metamorphosis](#), losing their chordate features and becoming adults. One group (class Larvacea) retain their larval characteristics throughout life.

typology: (1) The definition of classificatory groups by [phenetic](#) similarity to a "type" specimen. A species, for example, might be defined as all individuals less than x phenetic units from the species' type. (2) The theory that distinct "types" exist in nature, perhaps because they are part of some [plan of nature](#). (See also [idealism](#).) The type of the species is then the most important form of it, and variants around that type are noise, or "mistakes." Neo-Darwinism opposes typology because in a [gene pool](#) no one variant is any more important than any others.

unequal crossing-over: A [crossing-over](#) in which the two chromosomes do not exchange equal lengths of DNA; one receives more than the other.

Van Valen, Leigh: An evolutionary biologist who came up with the model of the Red Queen -- the living chess piece that Alice encounters in *Through the Looking Glass* who must keep running as fast as she can to stay in the same place -- as a metaphor to explain evolutionary patterns. His studies involve genetics and [systematics](#), and involve a wide range of topics, including the evolution of biotas and of mammals.

variance: A measure of how variable a set of numbers are. Technically, it is the sum of squared deviations from the mean divided by (n-1) (the number of numbers in the sample minus one). Thus, to find the variance of the set of numbers, 4, 6, and 8, we first calculate the mean, which is 6. We then sum the squared deviations from the mean $(4 - 6)^2 + (6 - 6)^2 + (8 - 6)^2$, which comes to 8, and divide by (n-1) (which is 2 in this case). The variance of the three numbers is $8/2 = 4$. The more variable the set of numbers, the higher the variance. The variance of a set of identical numbers (such as 6, 6, and 6) is zero.

Vermeij, Geerat J.: Biologist at the Center for Population Biology of the University of California at Davis, and author of *Privileged Hands: A Scientific Life*. Vermeij, blind since age 3, combines autobiography and description of the evolutionary "arms race" between intertidal predator and prey species. Wider research interests include economic relationships between organisms and ecosystems and their implications for human organisms.

vertebrates: The group (specifically, a subphylum) of animals, descended from a common ancestor, that share the derived character of an internal skeleton made of bone or cartilage.

vestigial: Any structures that have been greatly reduced in size and function over evolutionary time to the extent that they now appear to have little or no current function.

virulence: The disease-producing ability of a microorganism.

virus: A kind of intracellular [parasite](#) that can replicate only inside a living cell. In its dispersal stage between host cells, a virus consists of nucleic acid that codes for a small number of genes, surrounded by a protein coat. (Less formally, according to Medawar's definition, a virus is "a piece of bad news wrapped in a protein.")

vitamin A: A member of a chemically heterogeneous class of organic compounds that are essential, in small quantities, for life.

Von Mutius, Erika: A pediatrician and allergist, Dr. von Mutius's research interests include the epidemiology of childhood asthma and allergies with a focus on environmental predictors and gene-environment interactions.

Vrijenhoek, Robert: A senior scientist in the areas of evolutionary biology, marine biology, and conservation, Vrijenhoek studies the ecological and evolutionary consequences of genetic diversity in animals. His research efforts have focused on the evolutionary and ecological consequences of sexual and [asexual reproduction](#) in Mexican poeciliid fish (genus *Poeciliopsis*), as well as invertebrates in deep-sea hydrothermal vents.

Wake, David: A professor in the Department of Integrative Biology at the University of California at Berkeley, Dr Wake's research emphasizes analysis of evolutionary patterns and the processes that produce them, ranging from functional morphology to evolutionary genetics and population ecology. Amphibians and reptiles are the focus of his work.

Wallace, Alfred Russel: A British naturalist and contemporary of Charles Darwin. Wallace conducted research on the Amazon River and studied the zoological differences between animal species of Asia and Australia, developing a theory of evolution similar to Darwin's.

Ward, Peter Douglas: Professor of geological sciences at the University of Washington in Seattle, where he is also adjunct professor of zoology and of astronomy. Author of several books on biodiversity and the fossil record, including *Rivers in Time: The Search for Clues to Earth's Mass Extinctions* and *Rare Earth: Why Complex Life is Uncommon in the Universe* (with Donald Brownlee). He is the principal investigator for the University of Washington's portion of the NASA Astrobiology Institute.

Wegener, Alfred: A German climatologist and geophysicist whose book, *The Origins of Continents and Oceans*, was the first to propose the concept of continental drift (the forerunner to the theory of plate tectonics), as well as to suggest a supercontinent called Pangaea, which Wegener suggested had fragmented into the continents as we know them today. His ideas remained controversial until the 1960s, when they became widely accepted as new evidence led to the development of the concept of plate tectonics.

White, Tim: A paleoanthropologist with University of California, Berkeley's Laboratory for Human Evolutionary Studies, White is known for his meticulous fieldwork and analysis investigating early [hominid](#) skeletal biology, environmental context, and behavior. With an international team of colleagues, he discovered and named *Ardipithecus ramidus* and *Australopithecus garhi*.

wild type: The [genotype](#) or [phenotype](#), out of a set of genotypes or phenotypes of a species, that is found in nature. The expression is mainly used in lab genetics to distinguish rare mutant forms of a species from the lab stock of normal individuals.

Wilford, John Noble: A *New York Times* reporter and winner of two Pulitzer Prizes for his national reporting of science topics, and for his work on the Challenger explosion and the aftermath. While at the *Times* he served as science correspondent, assistant national news editor, and director of science news.

Wilson, E.O.: A biologist and professor at Harvard University since 1955. Wilson has won two Pulitzer Prizes for his books *On Human Nature* and *The Ants*, and has received numerous honors for his research and conservation efforts.

wobble: The ability of the third [base](#) in some anticodons of tRNA to bond with more than one kind of base in the complementary position in the mRNA codon.

Woese, Carl: A molecular biologist, Dr. Woese's identification of the Archaea as a distinctive group of organisms changed the way life is classified on Earth and transformed our view of biology.

Wrangham, Richard: A primatologist, Dr. Wrangham's central interest is in the significance of chimpanzee behavior, ecology, and life-history for

understanding the common ancestor between chimps and humans and subsequent human evolution.

young Earth creationism: The belief that the universe came into being only a few thousand years ago. Most young Earth creationists interpret the Bible literally, including not just the special, [separate creation](#) of human beings and all other species, but the historicity of Noah's flood.

zygote: The cell formed by the fertilization of male and female [gametes](#).

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